AD-A230 968

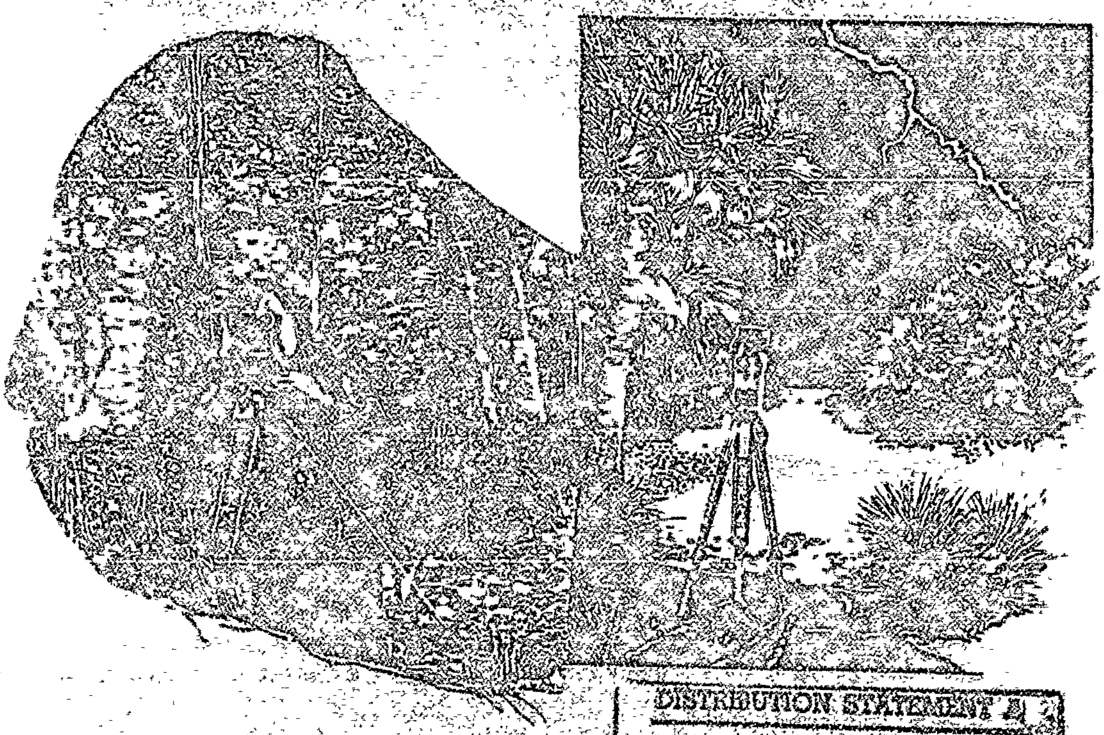
FINAL REPORT

1

# FIELD OPERATIONAL & ENVIRONMENTAL EVALUATION OF THE AUTOMATED INTEGRATED SURVEYING INSTRUMENT (AISI)



VOLUME I OF II





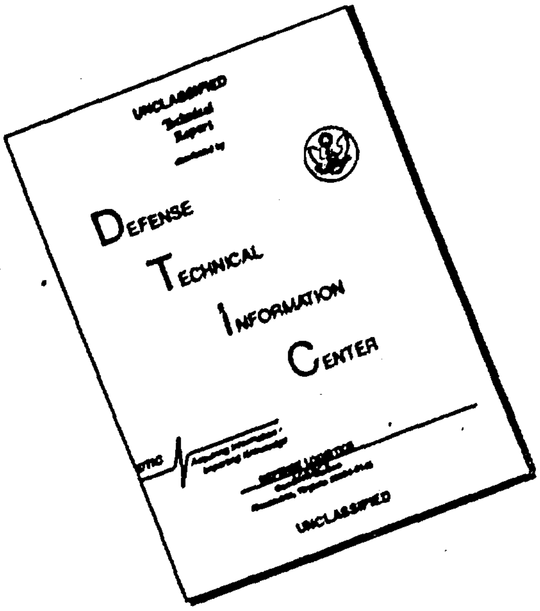
APRIL 1988

## COMBAT ENGINEERING DIRECTORATE
## COMBAT CONSTRUCTION DIVISION
## TOPOGRAPHIC EQUIPMENT



DEPARTMENT OF THE ARMY
U.S. ARMY BELVOIR RESEARCH, DEVELOPMENT AND ENGINEERING CENTER,
FORT BELVOIR, VIRGINIA 22060-5606

# DISCLAIMER NOTICE




THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

ADDENDUM (FINAL REPORT VOL. I OF II)

# FIELD OPERATIONAL & ENVIRONMENTAL EVALUATION OF THE AUTOMATED INTEGRATED SURVEYING INSTRUMENT (AISI)

MAY 1988

## CRITICAL TIME ELEMENTS

The times collected for various aspects of the AISI system's operations are considered to be representative of the times that could be expected of a well trained crew who performs survey activities every day. The times that would be expected of military survey crews would be greatly dependent on their training and experience and on the existing conditions. The times taken are based on interpretations of the criteria specified; as the exact meaning or parameters to be measured were not always clear.

### PREPARATION FOR MOVEMENT

| | |
|---|---|
| Time | 5 to 13.5 min. depending on how many prisms out, etc. |

### PREPARATION FOR FIELD OPERATIONS SET UP

| | |
|---|---|
| Distance | 5 minutes (10 readings @ 6 sec per reading). |
| Direction (angular) | 7 to 8 minutes depending on distance and number of repetitions of the angles. |

### CONDUCT DATA COLLECTION

| | |
|---|---|
| General concept | This is very subjective as it takes "no time" (nanoseconds) to transfer the data to the collector once the readings have been registered by the instrument. Therefore, the times have been adjusted to allow for the time spent in getting points located and set. |
| Distance | 2 min |
| Direction (angular) | 10 min (move from point to point) |
| Curve layout (per point) | 1 min (25 ft station) |
| Planetabling | 1 min (25 ft interval) |

### PROCESS FIELD DATA

| | |
|---|---|
| General concept | This is very subjective as there is time spent in transfering the data. The amount will depend upon the quantity to be transferred. Then there is time to edit. Any further processing is dependent upon what outputs are desired. Therefore, it is difficult to allocate a specific time to this function. |
| Topographic | 1 to 1.5 min per point to close a traverse |
| Construction | Same as topographic |

AUTOMATED INTERGRATION SURVEYING INSTRUMENT

(AISI)

## TABLE OF CONTENTS


| Topic | Volume I | Page |
|---|---|---|
| Table of Contents | | i |
| Figures | | ii |
| Abstract | | 1 |
| Preface | | 3 |
| Introduction | | 10 |
| Training Program | | 12 |
| Technical Documentation | | 15 |
| Field Evaluation | | 18 |
| Environmental Tests | | 29 |
| Electromagnetic interference Tests | | 34 |
| Operational and Environmental Testing | | 36 |
| Army Issues and Questions | | 42 |
| Test and Evaluation Command, Independent Evaluation Plan, Issues and Answers | | 43 |
| U.S. Army Engineer School Independent Evaluation Plan, Issues and Answers | | 73 |
| Belvoir Research, development and Engineer Center, Test and Evaluation Master Plan, Issues and Answers | | 84 |
| Conclusions | | 102 |
| Recommendations | | 103 |
| General Appendix | | 104 |

FIELD OPERATIONAL AND ENVIRONMENTAL EVALUATION

(AISI)

## FIGURES


| Number | Description | Page |
|---|---|---|
| 1 | Geodimeter 440 Front View | 4 |
| 2 | Geodimeter 440 Back View | 5 |
| 3 | Geodimeter 440 Side View | 6 |
| 4 | Wild T2000 Front View | 7 |
| 5 | Wild T2000 Back View | 8 |
| 6 | Wild T2000 Side View | 9 |
| 7 | Evaluation Survey Tasks | 19 |
| 8A | Geodimeter System 440 Specifications | 25 |
| 8B | Geodimeter Specification Notes | 26 |
| 9A | Wild T2000 Specifications | 27 |
| 9B | Wild Specification Notes | 28 |
| 10 | Reliability Test Traverse | 37 |
| 11 | AISI Reliability Test Function Procedures | 41 |
| 12 | Topographic Map - Appendix | J12 |
| 13 | Topographic Map - Appendix | J12 |

# AUTOMATED INTEGRATED SURVEYING INSTRUMENT

# (AISI)

## ABSTRACT

The Automated Integrated Survey Instrument (AISI) is an electronic surveying system capable of rapidly supplying the military surveyor with a single device that records vertical and horizontal angles and distances. It will overcome his greatest survey deficiency; lack of speed. As a total station concept, the AISI will perform all required surveying functions formerly achieved with theodolites and distance measuring equipment ~~devices~~, and will perform them with greater accuracy and fewer errors.

This survey speed deficiency was first identified in the Topographic Support System (TSS) Required Operational Capability (ROC) in 1978, and again recognized in the May 1983 Combat Support Engineering and Mine Warfare, Mission Area Analysis. Due to the inordinately high cost and sole source availability of an AISI unit in 1978, a decision was made to postpone the procurement but not delete the requirement. Later, after the Operational and Organizational (O&O) Plan for an AISI was approved by TRADOC in October 1986, a market investigation was conducted and a mission area analysis written disclosing that presently there were AISI devices being manufactured which could meet the U.S. Army's needs, and at much less cost than in 1978. The military units that can benefit most from the AISI are the topographic survey units, topographic and intelligence teams, and engineer construction units.

With the AISI requirement reconfirmed, operational and environmental evaluations were conducted on available AISI units. The results of these evaluations yielded data for assessing the benefits to the Army in overcoming the deficiency in survey operations. Environmental tests were performed and reported by a testing laboratory, while the field testing was shared by contractor personnel and Army

soldiers. The contractor personnel were novices to surveying while the soldiers had considerable surveying knowledge and experience.

AUTOMATED INTEGRATED SURVEYING INSTRUMENT

(AISI)

## PREFACE

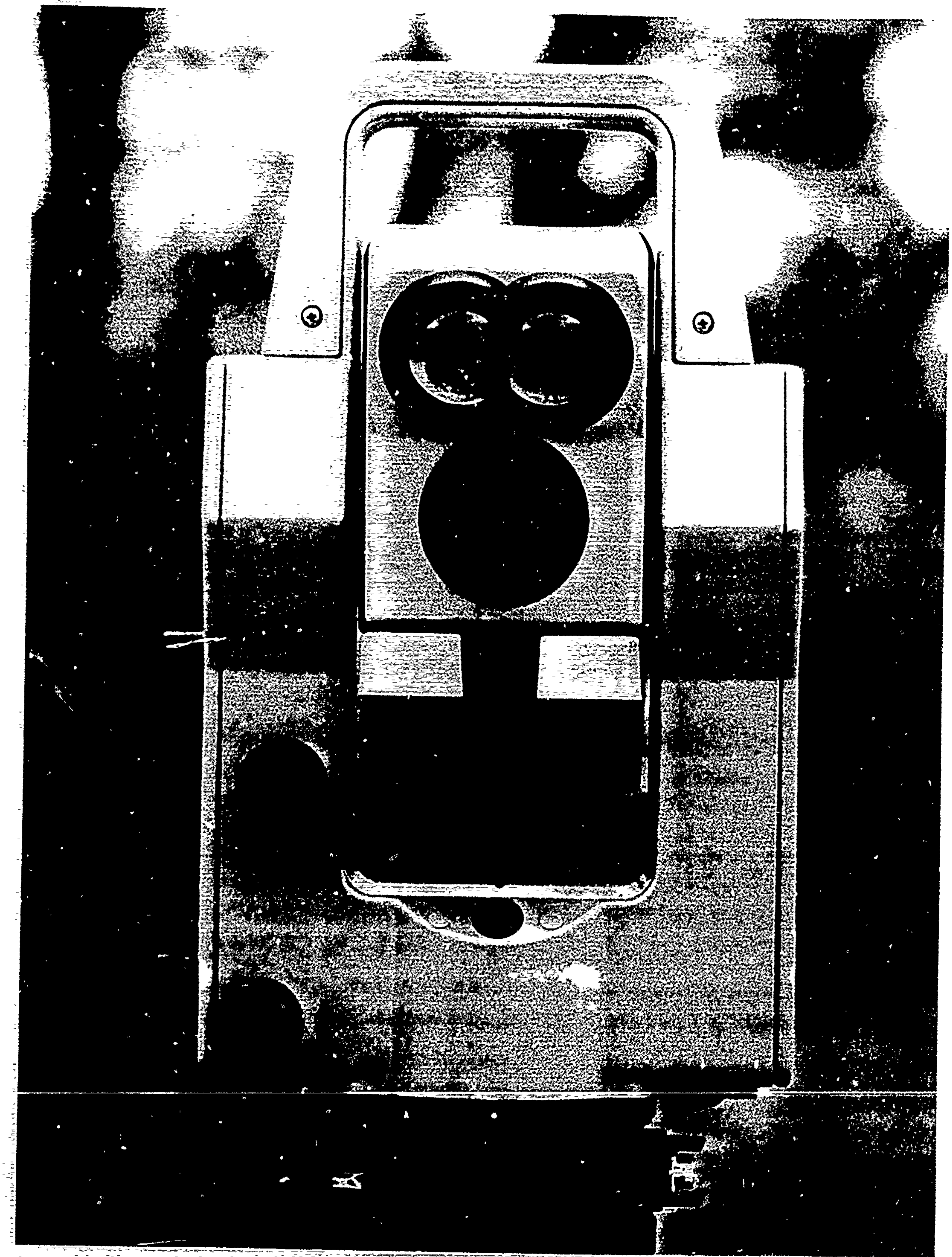
Presently AISI units are satisfying land survey company requirements by providing a "field to finish product" while saving time in field work, as well as office computations and drafting. Such was substantiated by investigating various manufacturers' suitability to meet Government requirements and by data gathering interviews with several land survey companies. With this as a background, the time was appropriate to conduct an evaluation of representative AISIs to determine their ability to increase data acquisition speed, and superior accuracy.

Three different models of AISIs, considered most likely to meet the Army's needs, were candidates for the evaluation. These models were:

- Cubic Precision; Model T1A
- Geodimeter Inc.; System 440 . . . . . . Figures 1,2, & 3
- Wild Heerbrugg; Model T2000 . . . . . Figures 4,5, & 6

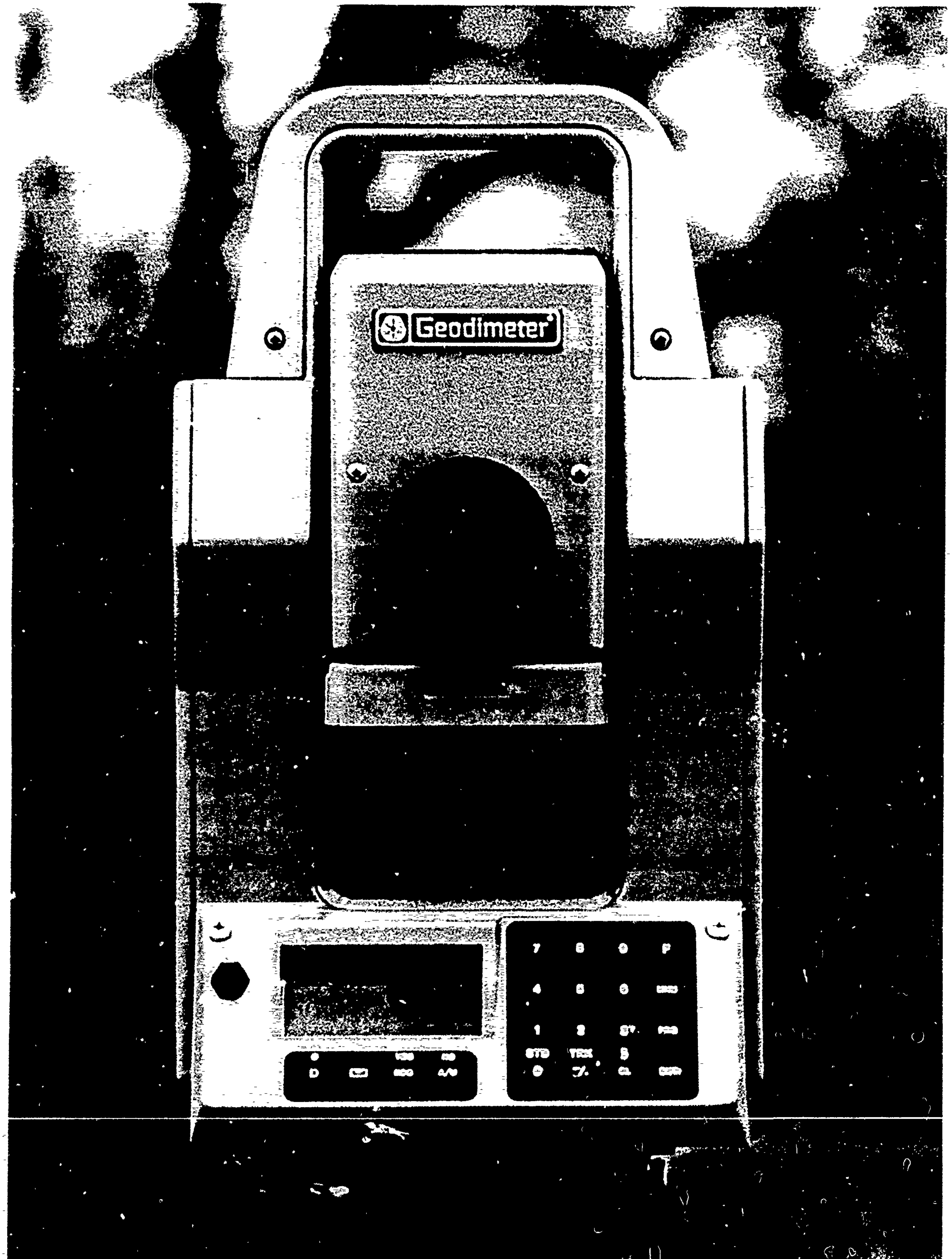
The operational and environmental evaluation would simulate those measurement and data acquisition techniques considered basic for topographic, construction, prebattle, battle, and postbattle surveys.

Previous to the evaluation, letters were sent out to the three candidate AISI companies asking the degree that each AISI could withstand the Government required standard environmental tests. Resulting correspondence verified that both the System 440 and Model T2000 should withstand environmental testing. In the Model T1A case, it was stated that due to its unique and research character it was not presently designed for environmental testing. As a result, only the System 440 and Model T2000 were considered for evaluation.



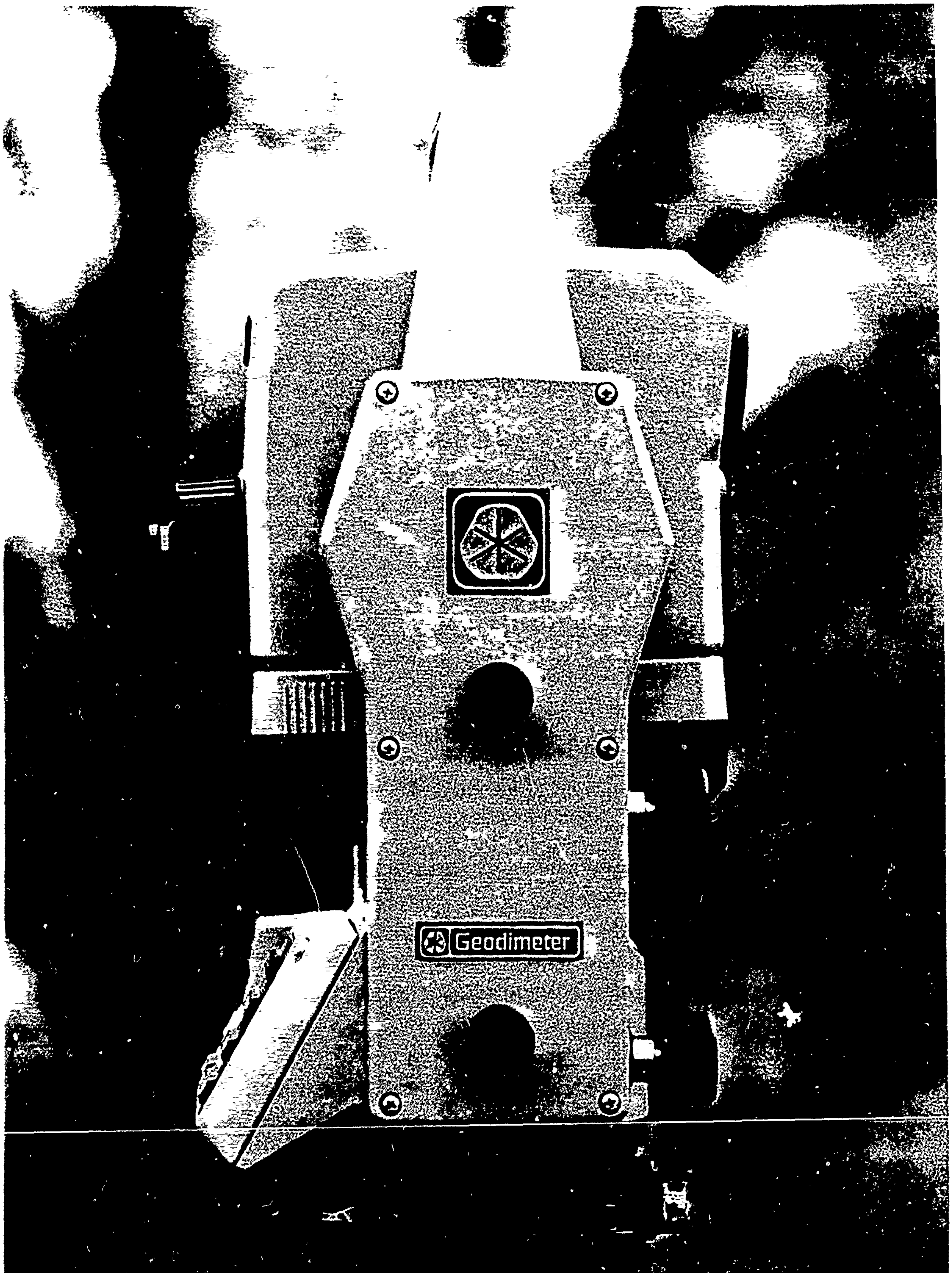
**FRONT VIEW**
(OBJECTIVE LENS)

FIGURE 1



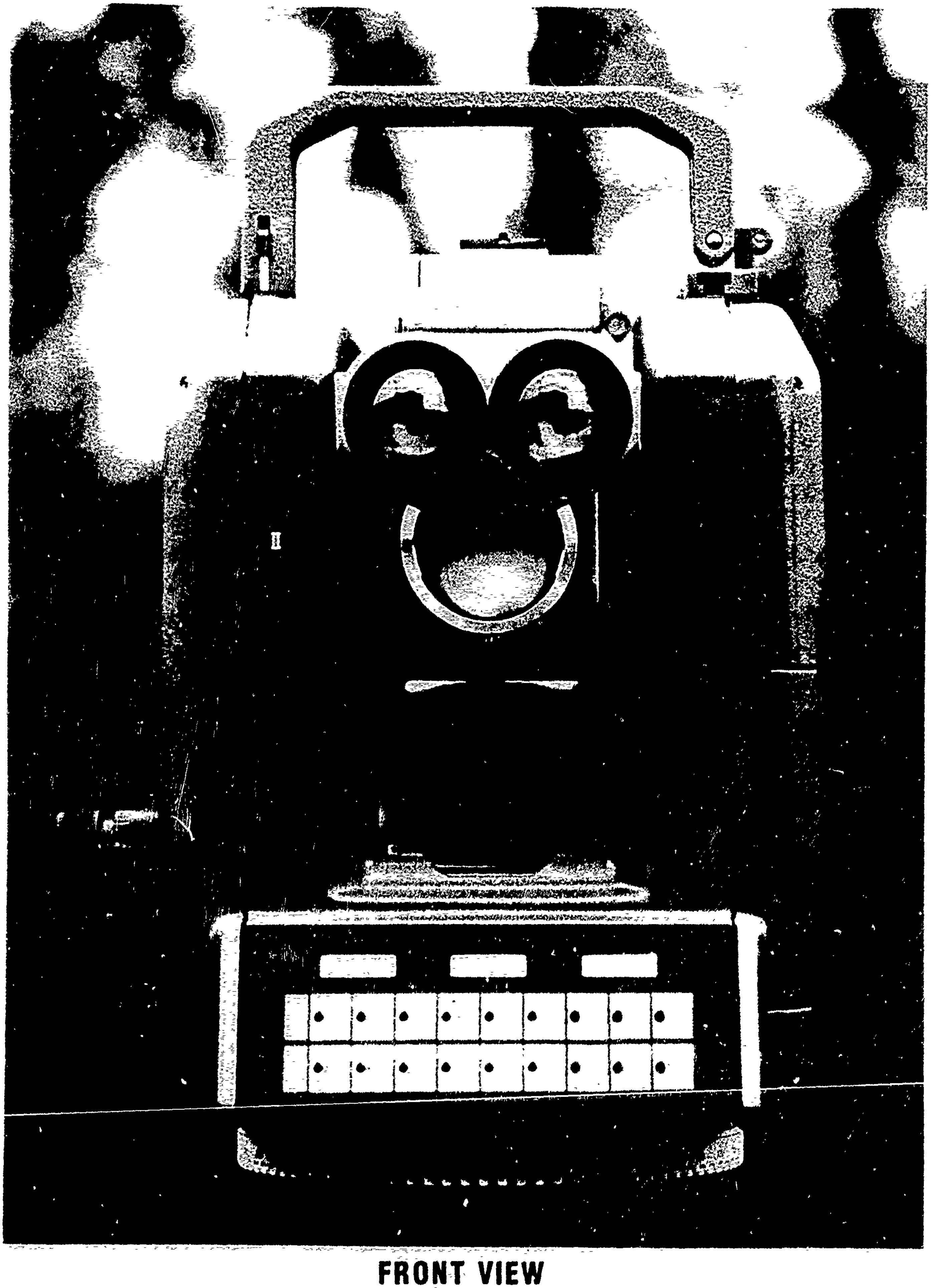

**BACK VIEW**
(EYEPIECE/SIGHTING LENS)

FIGURE 2



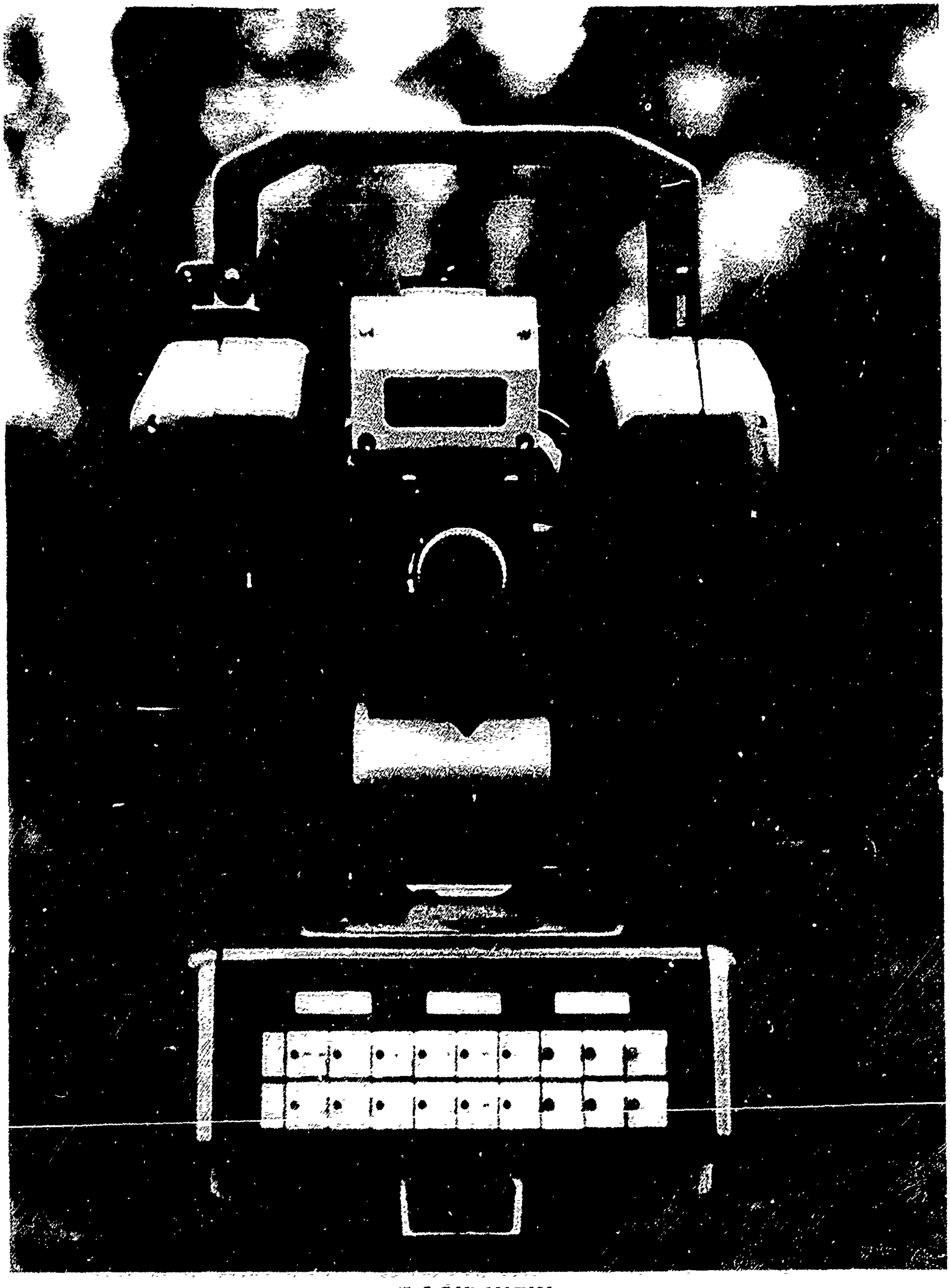

**SIDE VIEW**
(HORIZONTAL & VERTICAL MOVEMENT)
(COURSE & FINE ADJUSTMENT KNOBS)

FIGURE 3



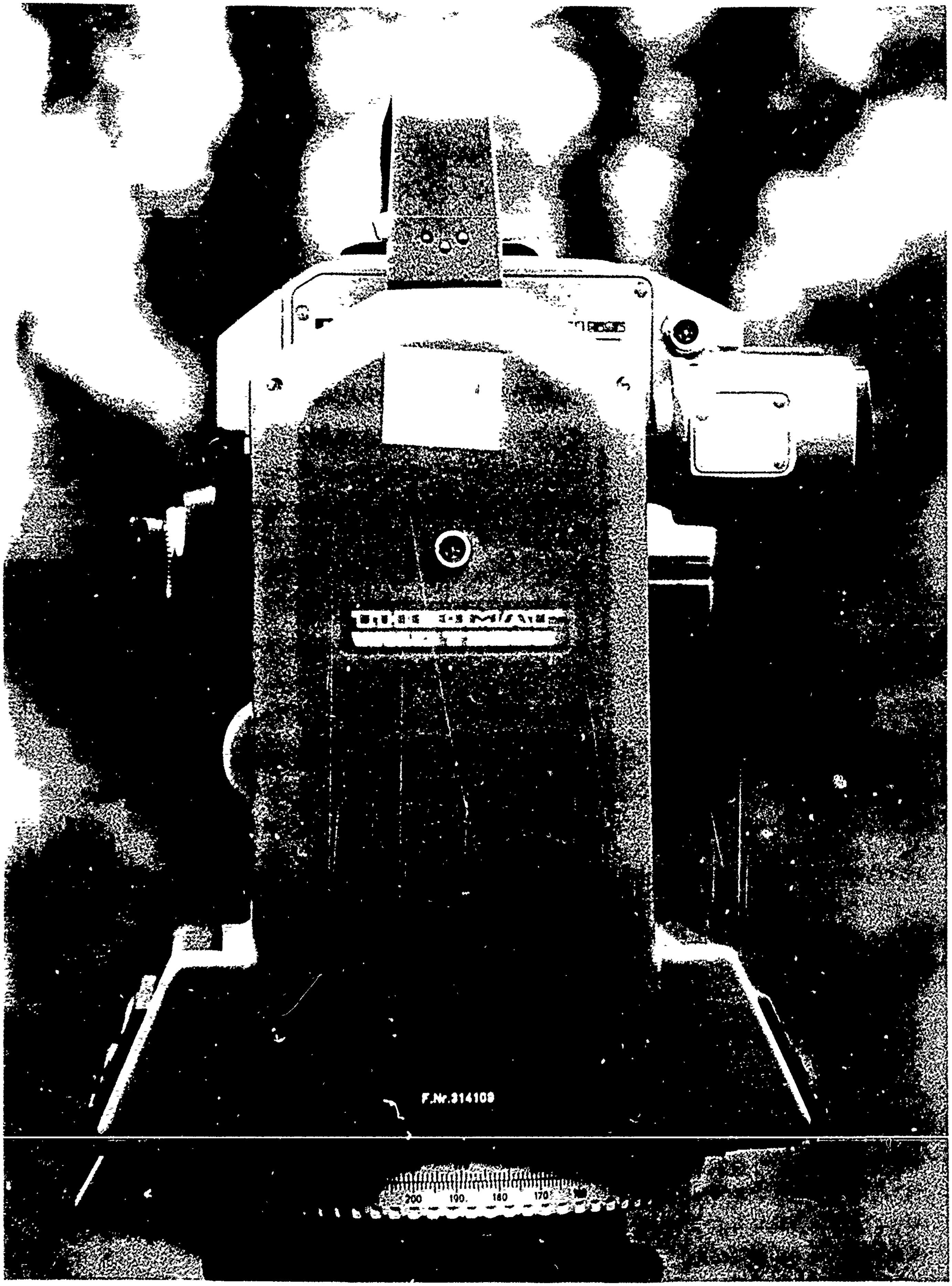
**FRONT VIEW**
(OBJECTIVE LENS)

FIGURE 4



**BACK VIEW**
(EYEPIECE/SIGHTING LENS)

FIGURE 5




**SIDE VIEW**
(HORIZONTAL & VERTICAL MOVEMENT)
(COURSE & FINE ADJUSTMENT KNOBS)

FIGURE 6

# AUTOMATED INTEGRATED SURVEYING INSTRUMENT

# (AISI)

## INTRODUCTION

This report addresses the results of the environmental, reliability, and field tests on two state-of-the-art survey instruments called the Automatic Integrated Surveying Instrument (AISI). The instruments, selected from a market investigation, automatically measure horizontal and vertical angles, and distances. A microprocessor is incorporated in the AISI units to calculate all the above measurements. The field survey results, malfunction codes, and prompting notations are displayed on the AISI instrument panels as the survey continues. The recorded data also can be routed to a portable data collector for later use in the office for data reduction, plotting or printing.

The AISIs combine an electronic distance measuring instrument, electronic digital theodolite and a microprocessor in one unit. Each instrument is about the size of a present-day standard theodolite, and by virtue of the multi-functional capability, weighs considerably more. The two AISIs tested were the Geodimeter, Model 440 and the Wild Theodolite, Model T2000.

The environmental tests were conducted by a nationally recognized testing contractor, while the reliability and field tests were performed by a private contractor and enlisted soldiers as observers.

The objective was to conduct the aforementioned tests, using the two AISI instruments, in order to ascertain their practical field utility, shortcomings and possible improvements. The results, from the tests are to be utilized in the following manner:

1. To determine to what degree the AISIs can withstand the specific environmental tests described in O/E/S Test Plan for Automated Integrated Surveying Instrument, (Volume II, Topic 1, buff pages).

2. To evaluate how the test results impact the Army's Test and Evaluation Master Plan for AISI (Volume II, Topic 3, yellow pages), and the two Independent Evaluation Plans for the Market Investigation of the AISI, Volume II (Topics 2, white pages and 6, blue pages).

3. To supply insight, information, and the basis for alternate or new requirements necessary for a more definitive AISI specification.

This report documents the evaluation results from field, environmental and reliability tests including conclusions and recommendations. The material presented is self contained and in two volumes (test results and source data) requiring no data or information other than that incorporated within the text.

## AUTOMATED INTEGRATED SURVEYING INSTRUMENT

## (AISI)

## TRAINING PROGRAM

The AISI training program was formulated and conducted based on the use of qualified and experienced survey personnel as trainees. Based on this starting point and after discussion with the personnel to be trained, a period of 8 hours maximum was set aside for training on each system to be evaluated. The training was conducted by the AISI manufacturers' representatives to assure that factual and pertinent information was taught.

The training program was structured to familiarize using personnel with the capability and functional operation of each system and not to teach surveying techniques. In addition; the use of data collection and transfer techniques was discussed, but no actual data transfer operations were conducted as part of the training program. This was done because the actual data transfer and processing was planned to be performed by data processing personnel with the assistance/advice of the surveying personnel. This process was planned to take advantage of available expertise.

Upon start of the field evaluation process, it was found that the familiarization training had been sufficient to teach system operating techniques necessary to perform the surveying processes planned. It was also discovered that the instruction manuals received with the system, which were being used for reference during the initial field learning stage, were difficult to use and were not well organized. The manual provided with the Wild system was particularly difficult

to use because of its attempt to provide information on several possible AISI configurations. This necessitated a great deal of page flipping back and forth to correlate actions.

As observers of the evaluation process, three military personnel who were trained and experienced surveyors, took part in a portion of the field procedures. While these personnel were not part of the evaluation team, their observations on instrument useability were requested. In all cases, their comments, both verbal and written, were: that trained surveyors should have little or no trouble learning to use the instruments.

A training program as detailed by the various military training program requirements document was not developed. Based on observation, it does not appear that any problems should be encountered in training personnel to use the electronic theodolite and electronic distance measuring equipment that were not encountered in training surveyors on conventional equipment. The training of personnel in the use of computers to process the data has not been addressed, as no basis for evaluation was available. It should be noted that all three military observers used the computer to familiarize themselves with the various data reduction programs being evaluated. They had no apparent trouble in using the computer to perform the tasks and in using the computer to input data for self-education purposes. This indicates that no major problem should be encountered in training individuals in data reduction.

The training aids to be used will be the actual equipment required to perform the task and should be considered adequate. Training aids that might be used to conduct the training on the theoretical aspects of surveying have not been addressed as no basis for their interface with the AISI system was available.

A negative feature in the training is with the commercial manuals provided with the systems. They will not serve well as training support items without revision into a simpler and more relatable format.

## AUTOMATED INTEGRATED SURVEYING INSTRUMENT

## (AISI)

## TECHNICAL DOCUMENTATION

The issue to be answered is as follows:

Is the technical documentation for the AISI accurate, comprehensive, and effective? The historical documentation utilized during the evaluation consisted of the commercial operator manuals that were provided with the systems.

### WILD-HEERBRUGG SYSTEM

In the case of Wild, the documentation consisted of an operator's manual for the instrument combined with some electronic distance measuring (EDM) device instructions. The manual covered several models of each. In addition, there was a small EDM manual, a data collector instruction manual, and a data processing program manual. The only maintenance instructions included were on the coaxial alignment of the telescope and EDM. The operator's manual describes the setup and initialization of the instrument and a series of checks that can be performed to verify instrument condition. It also describes the components and gives instructions on how to assemble them into an operating system. The manual contains instructions on setting various parameters on the instrument and on how to take and record measurement information as a block. It also provides instructions on how to set various output formats. The manual covers battery strength indicators and contains error message translation. In addition, it contains a series of pocket-sized cards containing short instructions and commands for the instrument, EDM, and data terminal. These were found to be very helpful and provided the clerical instructions in the documentation.

A major problem encountered was the inclusion of instructions for several equipment configurations, that also included references between the many different configurations for instructions on like items. This caused a great deal of page flipping during periods of familiarization. Basically, the instrument operator's manual was disorganized and lacked an index to help locate instructional items.

GEODIMETER

The Geodimeter system documentation contained a full-size operator's instruction manual, a small operator's manual that goes in the instrument carrying case, a data collector operating manual, and a data reduction program instruction manual. The instrument operator's manual was written in a relatively clear straightforward manner. The instructions progressed through the setup and initialization procedures step by step with illustrations showing what should appear on the screen at each step. The illustrations were good but could be improved by highlighting the action areas so they would stand out from the other information displayed. This would eliminate possible confusion as to which command goes with which response. The small operator's instruction manual contains essential operating instructions in the same format as the large one. Therefore, the same remarks apply.

The data collector's operator manual generally provides sufficient information to collect the data, organize, and transfer it to the computer for further processing. The manual is reasonably well written and is organized into sections of prepared programs in instructions and forms for preparing user programs. There are example illustrations to assist in user program preparation. In addition, the manual gives instructions on possible means of transferring programs prepared on other media to the data collectors. It also provides examples of various surveying programs for

practice in using the data collector. The data collector manual has an index and is generally easy to use in locating the information that is desired.

The computer software instruction manual is written on the premise that the reader has some knowledge of computer operations. This is a reasonable approach given the material that must be covered. The manual contents provide step-by-step instructions by process to be performed. The instructions are easy to follow and provide the user with required information to accomplish the tasks required to process the data through to completion. Examples of various output formats are included to allow comparison. In general, the manual . rrelates well with the program and provides information not readily available through the program itself.

CUBIC

An evaluation of material provided with the Cubic system was not completed, as the Cubic system was removed from evaluation before the midpoint was reached. The reason for removal was the manufacturer's negative response to questions concerning the ability of their equipment to pass planned environmental testing.

## AUTOMATED INTEGRATED SURVEYING INSTRUMENT

## (AISI)

## FIELD EVALUATION

The AISI field evaluation program was conducted to determine if the AISI equipment configuration would satisfy the military surveying requirements for second order type II work. The intent of the evaluation program was to validate the manufacturers specifications in accuracy and time of performance and to check the capability of the instruments and supporting hardware in their performance of topographic and construction surveying tasks. A series of known surveying tasks was developed for use in the evaluation, Figure 7. Analysis of the task list indicated that it was not necessary to perform each of the tasks, as there was a duplication of functions between various task elements (i.e. differences in elevation for topographic work is similar to setting grade in construction work); therefore data were not collected for every task. As a part of the field evaluation program it was necessary to make use of various software programs (equipment manufacturers and third party) to determine the compatibility of personnel, hardware, and software. The analysis of the software is contained elsewhere, but the products of the software are shown as attachments to the field evaluation.

To perform the field evaluation, the commercial surveying firm of Grissom Associates was selected. Mr. Evert Grissom, a registered land surveyor conducted all aspects of the field evaluation. Mr. Grissom's qualifications are detailed in Appendix B. In addition, three personnel from the Defense Mapping School at Ft. Belvoir, VA acted as observers of the field evaluation program. In this capacity the three personnel performed data collection and some data reduction actions to develop a "hands-on feel" so that their observations and comments would have

## EVALUATION SURVEY TASKS

1. Baseline
2. Accuracy
3. Horizontal Curve
4. Three Station Traverse
5. Four Station Traverse
6. Four and Three Station Traverse
7. Sun Shot
8. Star Shot
9. Maximum Range
10. Miscellaneous
11. Manual Input
12. Topographic

FIGURE 7

validity. Copies of the observations made by two of the three observers are in Appendixes C & D to the field evaluation report. Due to military requirements and a personal emergency, a report from the third observer was not available.

The field evaluation was conducted using a course laid out at the Belvoir RD&E Center Test Area, Fort Belvoir, VA. The course consists of a four station traverse, a three station traverse plus a connection to station four of the baseline, and a horizontal curve. In addition, the astronomical shot evaluation was conducted at Fort Belvoir because there was an available location from which the coordinates were verified. To determine the distance measuring accuracy of the systems, a baseline was established at Fort Belvoir and certified by a crew from the National Geodetic Survey on 18 March 1987. To establish maximum distance performance, a 7 kilometer shot was established by personnel of the 82nd Engineer Co. (SVY) on 20 February 1987. The baseline was located in Prince William County, Virginia with one station approximately 2.5 miles west of the town of Hickory Grove, VA, and the second approximately 2.1 miles northeast of the town of Woolsey, VA. The instrument used to establish the baseline distance was a WILD DI-20.

The field evaluation was started by giving the field crew orientation training on the various instruments that they would be using. Because the crew was experienced in survey procedures, it was determined that a maximum of 8 hours training would be all that was required for AISI operation. This training was conducted by the manufacturers' representatives and covered: the basic setup and operating procedures of the instrument, the standard data collection format set up by the manufacturer, and the steps necessary to customize the data collection format to accommodate data processing by third party software or to allow the incorporation of data collection formats the user might require. As a portion of the training, the interface requirements for data transfer for processing were

discussed. While the requirements were not such as to necessitate the use of a computer expert to accomplish the data transfer and processing, it was decided that a person qualified in data processing would be used, but data verification would be done by survey personnel. No problems were encountered during the training phase. However, it was determined that the instructional material provided as a part of the system (i.e, operating manuals, etc.) were not well designed and would present problems when used during the field evaluation.

Upon completion of the training phase the field crew was prepared to start conducting actual survey activities to gather data for demonstration of the systems' capabilities to satisfy stated requirements. The conduct of the maximum range evaluation was planned to be incorporated into the schedule whenever the atmospheric conditions appeared satisfactory. Field operations were conducted when atmospheric conditions permitted as in any survey activity. However, because the field crew also had to perform scheduled contracted commercial jobs as part of making a living, the inclement weather impact was greater than it otherwise might have been. Once in the field, it became apparent that some small amount of time would be required for the crew to really get a feel for the system they were employing. In addition, the actual productivity of the crew was lessened by having to go from the instruments and procedures they used on the job to those for the evaluation. This factor is considered to have contributed to some false starts and incomplete or incorrect format use. No blame can be attached to the equipment as it performed as programmed in each case. The standardization of equipment and its use in training the military surveyor will eliminate a possibility of having to use one type of equipment on the job and another in training.

Initial activities of the field crew were to determine that the instruments to be used were operating within manufacturers' specifications. This was done through the use of a level trier for check of the automatic compensator function and a

horizontal and vertical collimation check. Results of these checks are not reported as they served only to verify the correctness of the equipment condition, not its performance capability. Once it had been determined that the equipment was operating within specifications, the actual field activities were started.

The initial field operations were to run distance measurements over the baseline established at Fort Belvoir. Ten measurements were made for each distance for each instrument. The results of the measurements are shown in Appendix J-1. Upon completion of the distance measurement program, a series of horizontal and vertical reversion measurements were made. Six direct and reverse readings were taken on each instrument by three separate teams of personnel. The results of these readings are shown in Appendix J-2. At the conclusion of these readings, the routine type survey actions to be demonstrated, were started. During the conduct of these actions, horizontal and vertical angles were turned, distances measured, coordinates carried, elevations calculated and/or carried forward, automatic and manual point incrementation used, instrument to data recorder and data recorder to instrument transfer completed, and the changing of data recording format accomplished. Results of the various survey procedures are contained in Appendixes J3 through J12. T. ults for specific parameters are shown as answers to the specific criteria contained in the independent evaluation requirements. As a general statement the systems met the requirements for second order type II survey.

The evaluation started with three systems available for use. The initial check-out and the baseline and reversion procedures were conducted on all three systems. Upon entry into the routine field procedures, a letter was sent to each of the equipment manufacturers detailing the environmental tests that were to be conducted and requesting comments as to the ability of their equipment to pass such tests. Two affirmative responses were received. A third response indicated that company's equipment was considered highly sensitive and had not been designed

to survive under the conditions being imposed (MIL-STD-810). At this point the third system was considered unacceptable and was removed from further consideration as a candidate item. Therefore, the evaluation results contain data from only two systems, and the response to the independent evaluation questions are based on the two systems.

During the maximum range evaluation (7 km) in 1987 only the Wild T2000 passed the initial trial. The Geodimeter 440 system would not measure the maximum distance using the amount of prisms stated by the requirements or by the manufacturer. An inquiry placed with the manufacturer disclosed that diodes used in the system under evaluation had been found to be defective in that initially they performed to specifications but in a short time their performance deteriorated to about 60% of specification with a consequent deterioration of instrument performance. The manufacturer further stated that action to solve the problem was under way and that more information would be furnished later on. In late 1987 the manufacturer's representative indicated that instruments, with new circuitry components were available and a new instrument would be provided, on loan, to perform a maximum range evaluation. The instrument was furnished, and in late February 1988 with favorable atmospheric conditions, equipment and personnel, the Geodimeter 440 with newly installed diodes was tested, and instrument performed satisfactorily, meeting all requirements. The instrument used is the standard one currently offered for sale to any buyer. The company is currently in process of taking corrective action on all instruments sold that contained defective components.

It should be noted that neither system passed the radiated emission test. Inquiry has been made to each manufacturer as to possible reasons for failure, and if corrective action is to be taken. As to date, no response had been received.

Performance characteristics and manufacturers' specifications for each system are contained in Figures 8A & 8B and 9A & 9B. Because the evaluation was performance oriented, the manufacturers' specifications were accepted as being valid.

| MANUFACTURER/DISTRIBUTOR | FENNEL | GEODIMETER | GEODIMETER | GEODIMETER |
|---|---|---|---|---|
| MODEL | FET 2 | 410 | 420/440 | 142 |
| MANUFACTURER (If not same as Mfr./Distr.) | | Geotronics AB | Geotronics AB | Geotronics AB |
| U.S. SUGGESTED LIST PRICE | Ten options | $14 950 | $17 550/20 950 | $27 250 |
| CLASSIFICATION | Automatic | Automatic | Automatic | Automatic |
| CONFIGURATION [Self-Contained or Modular (Separate EDM unit)] | Modular | Self-Contained | Self-Contained | Self-Contained |
| DISTANCE MEASURING COMPONENT | | | | |
| Type | Pulsed laser | Infrared | Infrared | Infrared |
| Range (normal conditions), meters | | | | |
| To Single Prism | 2500 | 1000 | 1500/2300 | 2500 |
| To Triple Prism | 3000 | 1800 | 2200/3200 | 3600 |
| Accuracy, Standard Deviation | ±(5mm + 5ppm) | ±(3mm + 3ppm) | ±(3mm + 3ppm) ±(2mm + 3ppm) | ±(2mm + 3ppm) |
| Measuring Time, seconds | | | | |
| Single-Reading Mode | — | 5-7 | 5-7 | 5-10 |
| Auto-Ranging Mode — Fine, Coarse | 1, — | 0.4[1] | 0.4[1] | 0.4[1] |
| Type of Display | LCD | 4-line LCD | 4-line LCD | LED |
| Distance Correction Ranges | | | | |
| Atmospheric, ppm | - 99/ + 99 | - 60/ + 195 | - 60/ + 195 | - 50/ + 100 |
| Prism Offset, mm | -300/ + 300 | -999/ + 999 | -999/ + 999 | -999/ + 999 |
| Auto. Correction for Curvature and Refraction | No | Yes | Yes | Yes |
| Built-In Slope Reduction | Yes | Yes | Yes | Yes |
| Stake-Out Capability (Displays distance from prism to stake-out point) | No | Yes | Yes | With data collector |
| Other Distance Measuring Features | EDMs for hydrographic, distances w/o prisms, etc | [1] | [1] | [1] |
| ANGLE-MEASURING COMPONENT | | | | |
| Telescope | | | | |
| Coaxial with EDM Beam | No | No | No | No |
| Magnification | 25X | 30X | 30X | 30X |
| Field of View, degrees & minutes | 1°44' | 1°30' | 1°30' | 1°30' |
| Minimum Focusing Distance, meters | 2, adjustable | 1.3 | 1.3 | 1.3 |
| Reversible (may be "plunged") | Yes | Yes | Yes | Yes |
| Tilt Range, up/down (and with elbow) | + 50/ - 50(No elbow) | + 40/ - 70( + 55/ - 75) | + 40/ - 70( + 55/ - 75) | + 40/ - 50 |
| Horizontal Circle | | | | |
| Accuracy [Standard deviation of a direction, direct and reversed (DIN specification)] | ±16" | ±3" | ±2"/±1" | 1" |
| Optical Micrometer | | | | |
| Smallest Scale Division | — | — | — | — |
| Possible Estimation | — | — | — | — |
| Electronic Micrometer | | | | |
| Smallest Unit Detected | 1" | 0.3" | 0.3" | 0.3" |
| Smallest Unit Displayed | 1" | 1" | 1" | 1" |
| Can be Oriented to Zero After Pointing Telescope | Yes | Yes | Yes | Yes |
| Can be Oriented to Other Circle Reading After Pointing | Yes | Yes | Yes | With data collector |
| Automatic Correction of Horizontal Angle if Not Level | No | Yes | Yes | Yes |
| Vertical Circle | | | | |
| Optical Micrometer | | | | |
| Smallest Scale Division | — | — | — | — |
| Possible Estimation | — | — | — | — |
| Electronic Micrometer | | | | |
| Smallest Unit Detected | 1" | 0.3" | 0.3" | 0.3" |
| Smallest Unit Displayed | 1" | 1" | 1" | 1" |
| Other Angle Measuring Features | | | | |
| Stores Collimation and Vertical Index Corrections after D & R | — | Yes | Yes | Yes |
| Reads Left and Right | — | Yes | Yes | No |
| Selectable Display | — | 1", 10", 1' | 1", 10", 1' | No |
| Other | | | | |
| MISCELLANEOUS | | | | |
| Built-In Optical Plummet, Magnification | No 2X | No | No | No |
| Leveling Base | | | | |
| Plate Vial Sensitivity per 2mm | 40" | 20" electronic | 20" electronic | 20" |
| Detachable Tribrach | | Yes | Yes | Yes |
| Type, Plummet | Wild/Yes | Wild/Yes | Wild/Yes | Wild/Yes |
| Data Collector | | | | |
| Built-In, Optional, or N/A | Standard | Optional[1] | Optional[1] Built-in[1] | Optional |
| Price, if optional | Integrated | $1300-4450[2] | $1300-4450[1,2] | $4450 |
| Calculation Features | | | | |
| Determines ΔX, ΔY, and ΔZ | Yes | Yes | Yes | With data collector |
| Extracts Recorded Station Coordinates from Memory | No | With data collector | With data collector/optional | With data collector |
| Permits Entering Station Coordinates, Displays X, Y, Z of Point Sighted | With calculator connected | Yes | Yes | With data collector |
| Reduces (averages) Angles Measured by Repetition and/or Direction Method | — | Yes | Yes | With data collector |
| Alphanumeric Display | Yes | Yes | Yes | — |
| Three-Point Resection | With calculator connected | With data collector | With data collector/optional | With data collector |
| Remote Elevation Measurement | Yes | Yes | Yes | — |
| Missing Line (Distance and Difference in elevation) | No | With data collector | With data collector/optional | With data collector |
| Layout Method | | | | |
| Displays 3-Dimensional Corrections from Trial Point | No | With data collector | With data collector/optional | With data collector |
| Polar Coordinates by Inversing | No | With data collector | With data collector/optional | With data collector |
| Type of Target Required | | | | |
| Corner Cube or Rectangular Prism | Either | Cube | Cube | Cube |
| Centric or Eccentric Target | Eccentric | Eccentric | Eccentric | Eccentric |
| Other Features | | | | |
| Hand-Held Control Unit | No | With data collector | With data collector | With data collector |
| Back Pack | No | Yes | Yes | Yes |
| BATTERY | | | | |
| Built-In | Yes | Yes | Yes | No |
| Type | Lead acid | NiCd | NiCd | NiCd |
| Hours Continuous Use | 2000 measurements | 2 | 2 | 2 (Optional 12) |
| Weight, lbs. | 5.7 | 1.6 | 1.6 | 2.2 (Opt. 12-5.3) |
| CHARGER | | | | |
| Hours to Recharge | 14 | 8 | 8 | 8 |
| Overcharge Protection | Yes | Yes | Yes | Yes |
| Weight, lbs. | 1.8 | 0.56 | 0.56 | 0.56 |
| WEIGHT OF INSTRUMENT, lbs. | 26.4 | 17.4 | 17.4 | 24.3 |
| WARRANTY, Months | 12 | 12 | 12 | 12 |
| DATE OF INTRODUCTION, Month and Year | 9-84 | 1-88 | 1-87/7-88 | 5-87 |
| READER RESPONSE NUMBER | 700 | 701 | 702 | 703 |





FIGURE 8A

| | |
|---|---|
| MANUFACTURER/DISTRIBUTOR | ZEISS |
| MODEL | ELTA 3/4C |
| MANUFACTURER (If not same as Mfr./Distr.) | |
| U.S. SUGGESTED LIST PRICE | $17,860/13,986 |
| CLASSIFICATION | Automatic |
| CONFIGURATION [Self-Contained or Modular (Separate EDM unit)] | Self-Contained |
| DISTANCE MEASURING COMPONENT | |
| Type | Infrared |
| Range (normal conditions), meters | |
| To Single Prism | 1600 |
| To Triple Prism | 2500 |
| Accuracy, Standard Deviation | ±(3mm + 3ppm) |
| Measuring Time, seconds | |
| Single-Reading Mode | 5 7 |
| Auto-Ranging Mode—Fine, Coarse | 5 7 5.2 |
| Type of Display | LCD |
| Distance Correction Ranges | |
| Atmospheric, ppm | Input temp. and press. |
| Prism Offset, mm | -128/+128 |
| Auto. Correction for Curvature and Refraction | Yes, K = 0.13 |
| Built-in Slope Reduction | Yes |
| Stake-Out Capability (Displays distance from prism to stake-out point) | Yes |
| Other Distance Measuring Features | |
| ANGLE-MEASURING COMPONENT | |
| Telescope | |
| Coaxial with EDM Beam | Yes |
| Magnification | 30X |
| Field of View, degrees & minutes | 1°22' |
| Minimum Focusing Distance, meters | 1.0 |
| Reversible (may be "plunged") | Yes |
| Tilt Range, up/down (and with elbow) | ±55(±80) |
| Horizontal Circle | |
| Accuracy [Standard deviation of a direction, direct and reversed (DIN specification)] | ±2" ±3" |
| Optical Micrometer | |
| Smallest Scale Division | — |
| Possible Estimation | — |
| Electronic Micrometer | |
| Smallest Unit Detected | 1"2" |
| Smallest Unit Displayed | 1" 2" |
| Can be Oriented to Zero After Pointing Telescope | Yes |
| Can be Oriented to Other Circle Reading After Pointing | Yes |
| Automatic Correction of Horizontal Angle if Not Level | Yes/No |
| Vertical Circle | |
| Optical Micrometer | |
| Smallest Scale Division | — |
| Possible Estimation | — |
| Electronic Micrometer | |
| Smallest Unit Detected | 1" 2" |
| Smallest Unit Displayed | 1"/2" |
| Other Angle Measuring Features | |
| Stores Collimation and Vertical Index Corrections after D & R | Yes |
| Reads Left and Right | Yes |
| Selectable Display | No |
| Other | |
| MISCELLANEOUS | |
| Built-in Optical Plummet, Magnification | Yes, 2X |
| Leveling Base | |
| Plate Vial Sensitivity per 2mm | 30" |
| Detachable Tribrach | Yes |
| Type, Plummet | Wild/With or without |
| Data Collector | |
| Built-in, Optional, or N/A | Optional (two) |
| Price, if optional | $3375, 4660 |
| Calculation Features | |
| Determines ΔX, ΔY, and ΔZ | Yes |
| Extracts Recorded Station Coordinates from Memory | With data collector |
| Permits Entering Station Coordinates, Displays X, Y, Z of Point Sighted | Yes |
| Reduces (averages) Angles Measured by Repetition and/or Direction Method | With data collector |
| Alphanumeric Display | Yes (4 lines) |
| Three-Point Resection | With data collector |
| Remote Elevation Measurement | Yes |
| Missing Line (Distance and Difference in elevation) | Yes |
| Layout Method | |
| Displays 2-Dimensional Corrections from Trial Point | Yes |
| Polar Coordinates by Inversing | With data collector |
| Type of Target Required | |
| Corner Cube or Rectangular Prism | Cube |
| Centric or Eccentric Target | Concentric |
| Other Features | |
| Hand-Held Control Unit | No |
| Back Pack | Optional |
| BATTERY | |
| Built-in | Yes |
| Type | NiCd |
| Hours Continuous Use | 8-10 |
| Weight, lbs. | 0.8 |
| CHARGER | |
| Hours to Recharge | 12 rapid, 60 trickle |
| Overcharge Protection | Yes |
| Weight, lbs. | 2.4 |
| WEIGHT OF INSTRUMENT, lbs. | 13.8/13.8 |
| WARRANTY, Months | 12 P&L |
| DATE OF INTRODUCTION, Month and Year | 3-87/10-87 |
| READER RESPONSE NUMBER | 728 |



# Total Station

## NOTES

1. Collimation and vertical index corrections.
2. Distance meter matches offset of Kern prisms.
3. With DIF41 interface and HP-41CV calculator.
4. Remote receiver on sight rod.
5. With EDM installed, an eyepiece prism may be used, but not an elbow eyepiece.
6. Angle preset and hold using data collector.
7. Kern models are available with detachable tribrachs that fit either Wild or Zeiss, and the Kern auto-centering base with two screws incorporating a center pivot for fixed instrument height.
8. Can read CCW. Can retain last azimuth. Selectable round-off, mils.
9. Choice of Double Capacity Data Collector or HP-41 Module Data Collector.
10. Angle and distance readouts fall to zero as stake-out point is found.
11. 24-months for electronics; lifetime for mechanical-optical.
12. Operates with handle removed. Can sight up vertically with diagonal eyepiece.
13. With plummet in tribrach, both plummets operate.
14. SRC-5 and DK-5 calculators are separate from data collector, FC-1.
15. Accepts various EDMs as follows:

| Wild EDM Instrument | No. of Prisms | Range, meters | Accuracy |
|---|---|---|---|
| DISTOMAT DI1000 | 1<br>3 | 800<br>1200 | 5 mm + 5 ppm |
| DISTOMAT DI5S | 1<br>3 | 2500<br>3500 | 3 mm + 2 ppm |
| DISTOMAT DI2000 | 1<br>3 | 2000<br>2800 | 1 mm + 1 ppm |
| DISTOMAT DI3000 | 1<br>3 | 6000<br>7000 | 5 mm + 1 ppm |
| DISTOMAT DIOR3002 | None | 100 to 250 | 5 to 10 mm |
| | 1<br>3 | 4000<br>5000 | 5 mm + 1 ppm |

16. Continuous tracking of H and V angles.
17. Options include Tracklight to emit light signals for stake-out work, and Unicom for speech transmission via the measuring beam. Also, a number of optional function programs may be added to the 400 series instruments. Model 440 has internal memory option for 900 points.
18. Optional video camera.
19. Model 140S has manual control; Model 140T has automatic tracking up to 18 knots.
20. Internally illuminated.
21. The DK-5, which has reduction capabilities, functions as a calculator when plugged into the GT3-3B; $375.00.
22. Capable of inversing with an on-board manual keyboard.
23. Lower price is for pure data collector, higher price is for data collector with field calculator.
24. Measure time — 5" from second shot; tracking time — 0.6" from third shot.
25. Single auto-ranging mode.

**MANUFACTURER/DISTRIBUTOR ADDRESSES**
**(Maintenance Facility Locations)**

**geo-FENNEL, Führer & Co.**
Mühlenbergstr. 23
D-3507 Baunatal 6
West Germany

**Geodimeter, Inc.**
385 Bel Marin Keys Blvd.
Novato, CA 94947
414/883-2367
(Novato, CA)

**IR Inc.**
3025 Edgewater Dr.
Orlando, FL 32804
305/423-7882
(Orlando, FL)

**Jena Scientific Instruments**
820 Second Ave.
New York, NY 10017
212/867-3061

**Kern Instruments, Inc.**
Geneva Rd.
Brewster, NY 10509
914/279-5086
(Brewster, NY)

**The Lietz Company**
9111 Barton St.
Overland Park, KS 66201
913/492-4900
(Overland Park, KS)

**Nikon, Inc.**
19601 Hamilton Ave.
Torrance, CA 90502
213/516-7124
(Torrance, CA)

**Pentax Corp.**
35 Inverness Dr. E.
Englewood, CO 80112
303/799-8000
(Denver, CO)

**Topcon Instrument Corp. of America**
65 W. Century Rd.
Paramus, NJ 07652
201/261-9450
(Paramus, NJ)

**Total Technologies**
14530 E. Fremont Ave.
Englewood, CO 80112
303/690-8402
(Englewood, CO)

**Wild Geodesy**
24 Link Dr.
Rockleigh, NJ 07647
201/767-1100
(Rockleigh, NJ)

**Carl Zeiss, Inc.**
One Zeiss Dr.
Thornwood, NY 10594
914/747-1800
(Thornwood, NY)

FIGURE 8B

P.O.B. 1988 Total Station SURVEY

| MANUFACTURER/DISTRIBUTOR | WILD | WILD | WILD | WILD |
|---|---|---|---|---|
| MODEL | TC1600 | T2000/2000S | TC2000 | T2002 |
| MANUFACTURER (If not same as Mfr./Distr.) | | | | |
| U.S. SUGGESTED LIST PRICE | $21,995 | $22,660-34,660[15] | $27,545 | $17,995 |
| CLASSIFICATION | Automatic | Automatic | Automatic | Automatic |
| CONFIGURATION (Self-Contained or Modular (Separate EDM unit)) | Self-Contained | Modular | Self-Contained | Modular |
| **DISTANCE MEASURING COMPONENT** | | | | |
| Type | Infrared | Infrared | Infrared | Infrared |
| Range (normal conditions), meters | | | | |
| To Single Prism | 2000 | 800-6000[15] | 2500 | 800-6000[15] |
| To Triple Prism | 2800 | 1200-7000[15] | 3500 | 1200-7000[15] |
| Accuracy, Standard Deviation | (3mm + 2ppm) | [15] | ±(2mm + 2ppm) | [15] |
| Measuring Time, seconds | | | | |
| Single-Reading Mode | 3.0 | Determined by | 6.5 | Determined by |
| Auto-Ranging Mode—Fine, Coarse | 0.8[15] | configuration | 2.5[15] | configuration |
| Type of Display | LCD, 2 lines | LCD on theodolite | LCD | LCD, 2 lines |
| Distance Correction Ranges | | | | |
| Atmospheric, ppm | -399/+399 | -999/+999 | -999/+999 | 399 - 399 |
| Prism Offset, mm | 999 - 999 | 99 - 99 | 99 - 99 | 999 - 999 |
| Auto. Correction for Curvature and Refraction | Yes | Yes | Yes | Yes |
| Built-in Slope Reduction | Yes | Yes | Yes | Yes |
| Stake-Out Capability (Displays distance from prism to stake-out point) | Yes[10] | Yes[10] | Yes[10] | Yes |
| Other Distance Measuring Features | | EDMs attach w/o cable | | |
| **ANGLE-MEASURING COMPONENT** | | | | |
| Telescope | | | | |
| Coaxial with EDM Beam | Yes | No | Yes | No |
| Magnification | 30X | 32X 13X to 43X zoom | 11X to 30X zoom | 32X |
| Field of View, degrees & minutes | 1 33 | 1 33 3 49 to 1 08 | 3 49 to 1 30 | 1 33 |
| Minimum Focusing Distance, meters | 1.7 | 1.2/0.8 | 0.9 | 1.7 |
| Reversible (may be "plunged") | Yes | Yes, except DI 3000 | Yes | Yes |
| Tilt Range, up/down (and with elbow) | +45/-55(90/55) | 48/55(90/55)/47/55(N/A) | +45/-55(90/55) | +48/-55(90/55) |
| Horizontal Circle | | | | |
| Accuracy (Standard deviation of a direction, direct and reversed (DIN specification)) | 1.8 | 0.5 | 0.5 | 0.5 |
| Optical Micrometer | | | | |
| Smallest Scale Division | — | — | — | — |
| Possible Estimation | — | — | — | — |
| Electronic Micrometer | | | | |
| Smallest Unit Detected | — | 0.1" | 0.1 | 0.1 |
| Smallest Unit Displayed | 1 | 0.1 | 0.1 | 0.1 |
| Can be Oriented to Zero After Pointing Telescope | Yes | Yes | Yes | Yes |
| Can be Oriented to Other Circle Reading After Pointing | Yes | Yes | Yes | Yes |
| Automatic Correction of Horizontal Angle if Not Level | No | No | No | Yes |
| Vertical Circle | | | | |
| Optical Micrometer | | | | |
| Smallest Scale Division | — | — | — | — |
| Possible Estimation | — | — | — | — |
| Electronic Micrometer | | | | |
| Smallest Unit Detected | — | 0.1 | 0.1 | 0.1 |
| Smallest Unit Displayed | 1" | 0.1" | 0.1" | 0.1 |
| Other Angle Measuring Features | | | | |
| Stores Collimation and Vertical Index Corrections after D & R | Yes | Yes | Yes | Yes |
| Reads Left and Right | Yes | Yes | Yes | Yes |
| Selectable Display | No | 0.1" to 10" | 0.1" to 10" | Yes |
| Other | | | | |
| **MISCELLANEOUS** | | | | |
| Built-in Optical Plummet, Magnification | No | Yes, 2X | Yes, 2X | Yes, 2X |
| Leveling Base | | | | |
| Plate Vial Sensitivity per 2mm | 30" | 30" | 30" | 8" |
| Detachable Tribrach | Yes | | | Yes |
| Type, Plummet | Wild/Yes | Wild/No | Wild/No | Wild/No |
| Data Collector | | | | |
| Built-in, Optional, or N/A | 16K on-board, 64K external | Optional | Optional | Optional 16K, 64K |
| Price, if optional | 16K $495, 64K $2995 | $2995 | $2995 | 16K $495, 64K $2995 |
| Calculation Features | | | | |
| Determines ΔX, ΔY, and ΔZ | Yes | Yes | Yes | Yes |
| Extracts Recorded Station Coordinates from Memory | Yes | Yes | Yes | Yes |
| Permits Entering Station Coordinates, Displays X, Y, Z of Point Sighted | Yes | Yes | Yes | Yes |
| Reduces (averages) Angles Measured by Repetition and/or Direction Method | Yes | Yes | Yes | Yes |
| Alphanumeric Display | Yes | Yes | Yes | Yes |
| Three-Point Resection | Yes | Only with data collector | Only with data collector | Yes |
| Remote Elevation Measurement | Yes | Yes | Yes | Yes |
| Missing Line (Distance and Difference in elevation) | Yes | Only with data collector | Only with data collector | Yes |
| Layout Method | | | | |
| Displays 3-Dimensional Corrections from Trial Point | With data collector | Only with data collector | Only with data collector | Brg. Dist. corr. |
| Polar Coordinates by Inversing | With extrn. data collector | Only with data collector | Only with data collector | With extrn. data collector |
| Type of Target Required | | | | |
| Corner Cube or Rectangular Prism | Either | Either | Either | Either |
| Centric or Eccentric Target | Centric | Eccentric | Centric | Eccentric |
| Other Features | | | | |
| Hand-Held Control Unit | No | N/A | N/A | N/A |
| Back Pack | Has back straps | Has back straps | Has back straps | Has back straps |
| **BATTERY** | | | | |
| Built-in | Yes | Yes | Yes | Yes |
| Type | NiCd | NiCd | NiCd | NiCd |
| Hours Continuous Use | 50 angles & dist | 1500 angles or 500 dist | 1500 angles or 500 dist | 1500 angles, 500 dist |
| Weight, lbs. | 0.44 | 1.8 | 1.8 | 1.8 |
| **CHARGER** | | | | |
| Hours to Recharge | 14 or less | 14 or less | 14 or less | 14 or less |
| Overcharge Protection | Yes | Yes | Yes | Yes |
| Weight, lbs. | 3.2 | 3.2 | 3.2 | 3.2 |
| WEIGHT OF INSTRUMENT, lbs. | 14.5 | 23.9-23.1 | 22.9 | 20.1 |
| WARRANTY, Months | 24 | 24 | 24 | 24 |
| DATE OF INTRODUCTION, Month and Year | 6-87 | 3-83/11-84 | 3-85 | 3-88 |
| READER RESPONSE NUMBER | 724 | 725 | 726 | 727 |



FIGURE 9A

| MANUFACTURER/DISTRIBUTOR | ZEISS |
|---|---|
| MODEL | ELTA 3/4C |
| MANUFACTURER (if not same as Mfr./D'tor ) | |
| U.S. SUGGESTED LIST PRICE | $17 850/13 995 |
| CLASSIFICATION | Automatic |
| CONFIGURATION (Self-Contained or Modular (Separate EDM unit)) | Self-Contained |
| **DISTANCE MEASURING COMPONENT** | |
| Type | Infrared |
| Range (normal conditions), meters | |
| To Single Prism | 1600 |
| To Triple Prism | 2500 |
| Accuracy Standard Deviation | ±(3mm + 3ppm) |
| Measuring Time seconds | |
| Single-Reading Mode | 5 7 |
| Auto-Ranging Mode—Fine, Coarse | 5 7 5 2 |
| Type of Display | LCD |
| Distance Correction Ranges | |
| Atmospheric, ppm | Input temp. and press |
| Prism Offset, mm | - 128/ + 128 |
| Auto. Correction for Curvature and Refraction | Yes K = 0 13 |
| Built-in Slope Reduction | Yes |
| Stake-Out Capability (Displays distance from prism to stake-out point) | Yes |
| Other Distance Measuring Features | |
| **ANGLE-MEASURING COMPONENT** | |
| Telescope | |
| Coaxial with EDM Beam | Yes |
| Magnification | 30X |
| Field of View degrees & minutes | 1°22' |
| Minimum Focusing Distance, meters | 1 0 |
| Reversible (may be "plunged") | Yes |
| Tilt Range, up down (and with elbow) | ±55(±60) |
| Horizontal Circle | |
| Accuracy (Standard deviation of a direction direct and reversed (DIN specification)) | ±2" ±3" |
| Optical Micrometer | |
| Smallest Scale Division | — |
| Possible Estimation | — |
| Electronic Micrometer | |
| Smallest Unit Detected | 1"2" |
| Smallest Unit Displayed | 1"2" |
| Can be Oriented to Zero After Pointing Telescope | Yes |
| Can be Oriented to Other Circle Reading After Pointing | Yes |
| Automatic Correction of Horizontal Angle if Not Level | Yes/No |
| Vertical Circle | |
| Optical Micrometer | |
| Smallest Scale Division | — |
| Possible Estimation | — |
| Electronic Micrometer | |
| Smallest Unit Detected | 1"2" |
| Smallest Unit Displayed | 1"2" |
| Other Angle Measuring Features | |
| Stores Collimation and Vertical Index Corrections after D & R | Yes |
| Reads Left and Right | Yes |
| Selectable Display | No |
| Other | |
| **MISCELLANEOUS** | |
| Built-in Optical Plummet, Magnification | Yes 2X |
| Leveling Base | |
| Plate Vial Sensitivity per 2mm | 30" |
| Detachable Tribrach | Yes |
| Type, Plummet | Wild/With or without |
| Data Collector | |
| Built-in, Optional, or N/A | Optional (two) |
| Price, if optional | $3375 4050 |
| Calculation Features | |
| Determines ΔX, ΔY, and ΔZ | Yes |
| Extracts Recorded Station Coordinates from Memory | With data collector |
| Permits Entering Station Coordinates, Displays X, Y, Z of Point Sighted | Yes |
| Reduces (averages) Angles Measured by Repetition and/or Direction Method | With data collector |
| Alphanumeric Display | Yes (4 lines) |
| Three-Point Resection | With data collector |
| Remote Elevation Measurement | Yes |
| Missing Line (Distance and Difference in elevation) | Yes |
| Layout Method | |
| Displays 2-Dimensional Corrections from Trial Point | Yes |
| Polar Coordinates by Inversing | With data collector |
| Type of Target Required | |
| Corner Cube or Rectangular Prism | Cube |
| Centric or Eccentric Target | Concentric |
| Other Features | |
| Hand-Held Control Unit | No |
| Back Pack | Optional |
| **BATTERY** | |
| Built-in | Yes |
| Type | NiCd |
| Hours Continuous Use | 8-10 |
| Weight, lbs. | 0 8 |
| **CHARGER** | |
| Hours to Recharge | 12 rapid 80 trickle |
| Overcharge Protection | Yes |
| Weight, lbs. | 2 4 |
| WEIGHT OF INSTRUMENT, lbs. | 13 0/13 5 |
| WARRANTY, Months | 12 P&L |
| DATE OF INTRODUCTION, Month and Year | 3-87/10-87 |
| READER RESPONSE NUMBER | 728 |

## NOTES

1. Collimation and vertical index corrections
2. Distance meter matches offset of Kern prisms
3. With DIF41 interface and HP-41CV calculator
4. Remote receiver on sight rod
5. With EDM installed, an eyepiece prism may be used, but not an elbow eyepiece
6. Angle preset and hold using data collector
7. Kern models are available with detachable tribrachs that fit either Wild or Zeiss, and the Kern auto-centering base with two screws incorporating a center pivot for fixed instrument height.
8. Can read CCW. Can retain last azimuth. Selectable round-off, mils
9. Choice of Double Capacity Data Collector or HP-41 Module Data Collector
10. Angle and distance readouts fall to zero as stake-out point is found.
11. 24-months for electronics; lifetime for mechanical-optical
12. Operates with handle removed. Can sight up vertically with diagonal eyepiece.
13. With plummet in tribrach, both plummets operate.
14. SRC-5 and DK-5 calculators are separate from data collector, FC-1
15. Accepts various EDMs as follows:

| Wild EDM Instrument | No. of Prisms | Range, meters | Accuracy |
|---|---|---|---|
| DISTOMAT DI1000 | 1 | 800 | 5mm + 5ppm |
| | 3 | 1200 | |
| DISTOMAT DI5S | 1 | 2500 | 3mm + 2ppm |
| | 3 | 3500 | |
| DISTOMAT DI2000 | 1 | 2000 | 1mm + 1ppm |
| | 3 | 2800 | |
| DISTOMAT DI3000 | 1 | 6000 | 5mm + 1ppm |
| | 3 | 7000 | |
| DISTOMAT DIOR3002 | None | 100 to 250 | 5 to 10mm |
| | 1 | 4000 | 5mm + 1ppm |
| | 3 | 5000 | |

16. Continuous tracking of H and V angles
17. Options include Tracklight to emit light signals for stake-out work, and Unicom for speech transmission via the measuring beam. Also, a number of optional function programs may be added to the 400 series instruments. Model 440 has internal memory option for 900 points.
18. Optional video camera
19. Model 140S has manual control, Model 140T has automatic tracking up to 18 knots
20. Internally illuminated
21. The DK-5, which has reduction capabilities, functions as a calculator when plugged into the GT3-3B: $375.00.
22. Capable of inversing with an on-board manual keyboard
23. Lower price is for pure data collector, higher price is for data collector with field calculator
24. Measure time — 5" from second shot, tracking time — 0.6" from third shot.
25. Single auto-ranging mode.

**MANUFACTURER/DISTRIBUTOR ADDRESSES**
**(Maintenance Facility Locations)**

**geo-FENNEL, Führer & Co.**
Mühlenbergstr. 23
D-3507 Baunatal 6
West Germany

**Geodimeter, Inc.**
385 Bel Marin Keys Blvd.
Novato, CA 94947
414/883-2367
(Novato, CA)

**IR Inc.**
3025 Edgewater Dr
Orlando, FL 32804
305/423-7892
(Orlando, FL)

**Jena Scientific Instruments**
920 Second Ave
New York, NY 10017
212/867-3051

**Kern Instruments, Inc.**
Geneva Rd.
Brewster, NY 10509
914/279-5095
(Brewster, NY)

**The Lietz Company**
9111 Barton St.
Overland Park, KS 66201
913/492-4900
(Overland Park, KS)

**Nikon, Inc.**
19601 Hamilton Ave.
Torrance, CA 90502
213/516-7124
(Torrance, CA)

**Pentax Corp.**
35 Inverness Dr. E.
Englewood, CO 80112
303/799-8000
(Denver, CO)

**Topcon Instrument Corp. of America**
65 W. Century Rd.
Paramus, NJ 07652
201/261-9450
(Paramus, NJ)

**Total Technologies**
14530 E. Fremont Ave.
Englewood, CO 80112
303/690-6402
(Englewood, CO)

**Wild Geodesy**
24 Link Dr
Rockleigh, NJ 07647
201/767-1100
(Rockleigh, NJ)

**Carl Zeiss, Inc.**
One Zeiss Dr
Thornwood, NY 10594
914/747-1800
(Thornwood, NY)

FIGURE 9B

# AUTOMATED INTEGRATED SURVEYING INSTRUMENT

# (AISI)

## ENVIRONMENTAL TESTS

Environmental tests were conducted in the summer 1987 by the National Technical Systems (NTS), D.C. Division, State Route 748, Hartwood, Virginia, upon the Geodimeter model 440, and Wild model T2000 Automated Integrated Surveying Instrument (AISI), total stations. Purpose of conducting these tests was to determine the AISIs' conformance to the requirements specified in the Operational/Environmental/Suitability Test Plan for the AISI (Volume II, Topic 1, buff pages).

Tests conducted were: high and low temperature operation, high and low temperature storage, humidity, sand and dust, rainfall, instrument vibration (in and out of case), solar radiation, and shock (in transport case). The Geodimeter instrument passed all tests except vibration out of case which was terminated. The Wild instrument failed the rainfall test, in that there was water in the transport carrying case. During the shock test and vibration in case test, the EDM misaligned. The vibration out of case test for both instruments was terminated almost immediately by the Radian Inc. representative, to prevent instruments from being shaken to destruction. No damage resulted to Geodimeter, but Wild EDM misaligned (corrected by Radian representative). The test was not considered representative of true environmental conditions. Both instruments received functional tests after each of the environmental tests to confirm AISI repeatability.

Summaries of the tests are presented below. A detailed description is in on NTS's Environmental Test report Volume II, Topic 4, pink pages. The tests start on page 2 of that report and progress to page 8. Pages beyond that identify test equipment used, the manufacturer, the numbering of the equipment, calibration date and due date. Temperature and vibration plots are illustrated, followed by a "Notice of Deviation" (vibration test termination) and photographs of equipment under test. The test data supporting the environmental tests are also included. The test summaries below are identified by the following headings:

| Heading | Description |
|---|---|
| (1) Item No. . . . . . . . . . . . | Chronological numbering of the tests. |
| (2) NTS Page No.. . . . . . . . | Page number of the NTS test report describing the particular test in detail. |
| (3) Environmental Test . . . . . | The name of the environmental test in the above NTS report. Also shown is the corresponding test number (roman) as it appears in the O/E/S Test Plan. |
| (4) Test Results . . . . . . . . | This column contains the results of the environmental tests of the two AISIs. |

## ENVIRONMENTAL TEST RESULTS

| (1) Item No | (2) NTS Page No. | (3) Environmental Test | (4) Test Results: Geodimeter, Model 440 | (4) Test Results: Wild, Model T2000 |
|---|---|---|---|---|
| 1 | 2 | High-Temperature Operation Test. (O/E/S Test Plan, test VII) | Instrument and equipment tested in 122°F chamber then room ambient temperature of 68°F. No visual damage apparent. | Instrument and equipment tested in same manner as Geod. 440 No visual damage apparent. |
| 2 | 2 | High Temperature Storage Test. (O/E/S Test Plan, test VIII.) | Instrument and equipment were tested in 160°F chamber, then lowered to room temperature. No visual damage apparent | Instrument and equipment were tested in same manner as Geod. 440. No visual damage apparent. |
| 3 | 3 | Low-Temperature Storage Test. (O/E/S Test Plan, test XVB.) | Instrument and equipment were tested in chamber at -50°F, then room temperature and dried out. No visual damage apparent. | Instrument and equipment were storage tested in same manner as Geod. 440. No visual damage apparent. |
| 4 | 4 | Low-TemperatureOperation Test. (C/E/S Test Plan, test XVA.) | Instrument and equipment were tested in chamber at -5°F, then room temperature. No visual damage apparent. | Instrument and equipment were tested in same way as Geod. 440. No visual damage noted. |
| 5 | 4 | Humidity Test. (O/E/S Test Plan, test XIII.) | Instrument and accessories were placed in humidity chamber at 120°F and 95% humidity, and tested. No visual damage noted. | Instrument and accessories tested in same way as Geod. 440. No visual damage noted. |

| (1) Item No. | (2) NTS Page No. | (3) Environmental Test | (4) Test Results: Geodimeter, Model 440 | Wild, Model T2000 |
|---|---|---|---|---|
| 6 | 5 | Sand and Dust Test. (O/E/S Test Plan, test XXX) | Instrument and case separately, were placed into sand and dust chamber with air velocity at 240 feet per minute, and tested. Caps covering vertical and horizontal fine-control knobs fell off during test. Main viewing lens metal ring rendered out of round. (May have occurred in earlier test.) | Instrument and case, separately tested in same way as Geod. 440. No visual damage noted. |
| 7 | 5 | Rainfall Test. (O/E/S Test Plan, test XVII.) | Instrument in operating position, and with case were placed in rain test setup and tested for one hour. No visual damage was apparent. | Instrument and case tested in same way as Geod. 440. Water 1/8-inch deep in case, and water inside bottom lens of telescope. |
| 8 | 6 | Vibration-AISI Equipment Out of Case. (O/E/S Test Plan, test XIX.) | Instrument rigidly secured to platform and vibrated in X axis only. Test was terminated by Radian Inc. representative as being excessive and potentially damaging to the instrument. No damage resulted. | Instrument rigidly secured to platform and subjected to same test, and terminated for same reason. Vibration caused misalignment to appear, but was corrected by Radian Inc. representative. |
| 9 | 6 | Vibration-AISI Equipment in Transport Case. (O/E/S Test Plan, test XX.) | Instrument in transport case rigidly mounted to vibration table and tested. Examined and no visual damage noted. | Instrument and case tested in same way as Geod. 440. Results: distance measuring unit misaligned to left. Required to aim to lower left for signal. |

| (1) Item No. | (2) NTS Page No. | (3) Environmental Test | (4) Test Results: Geodimeter, Model 440 | (4) Test Results: Wild, Model T2000 |
|---|---|---|---|---|
| 10 | 7 | Solar Radiation Test (O/E/S Test Plan, test X.) | Instrument, in operating position, placed in test chamber at 110°F with solar radiation of 335 Btu for 4 hours, IAW X. No visual damage noted. | Instrument tested in same way as Geod. 440. No visual damage noted. |
| 11 | 7 | Shock (In Transport Case). (O/E/S Test Plan, test XXI.) | Instrument in transport case, shock tested by flat-dropping and dropping on corners upon 2 inch plywood backed by concrete. Examined with no visual damage noted | Instrument and case, tested the same way as Geod. 440. Head aligning dowels and slots were badly worn, but did not prevent realignment, which was achieved by Radian Inc. representative. |

## AUTOMATED INTEGRATED SURVEYING INSTRUMENT

## (AISI)

## ELECTROMAGNETIC INTERFERENCE TESTS

The electromagnetic interference (EMI) tests were conducted by the NTS at their Acton, Massachusetts test facilities in late summer, 1987. One each of the Geodimeter, model 440 and the Wild, model T2000 were tested. These tests were performed under contract to Radian Inc. The contractor prepared a test report that also contains laboratory readings. The O/E/S Test Plan Volume II, Topic 1, buff pages lists test paragraph XXVIII, as guidance for the EMI tests. The test as performed by the contractor was in two parts; radiated interference electric field, and magnetic field susceptibility. The results are summarized below with the column headings defined as follows:

(1) Item No. . . . . . . . . . . . Chronological numbering of the tests.

(2) NTS EMI Page No. . . . . . Page number of the NTS test report describing the particular test in detail.

(3) EMI Test . . . . . . . . . . . Name of the test. Also, is the corresponding test number (roman) as it appears in the O/E/S Test Plan.

(4) Test Results . . . . . . . . . This column contains the results of the EMI test of the two AISIs.

## ELECTROMAGNETIC INTERFERENCE TEST RESULTS

| (1) Item No. | (2) NTS EMI Page No. | (3) EMI Test | (4) Test Results | |
|---|---|---|---|---|
| | | | Geodimeter, Model 440 | Wild, Model T2000 |
| 1 | 5-1 & 6-1 | Electromagnetic Interference (EMI). (Radiated Interference RE02 Electric Field 14 KHz to 10 GHz) (O/E/S Test Plan, test XXVIII.) | Instrument placed in shielded inclosure and measurements performed. The instrument failed narrowband frequency test. Cause not determined | Instrument tested in same manner as Geod. 440. Instrument failed narrowband frequency test. Cause not determined. |
| 2 | 5-1 & 6-16 | Electromagnetic Interference (EMI). (Magnetic Field Susceptibility). (O/E/S Test Plan, test XXVIII.) | Instrument placed at center of coil producing 8 gauss. Ten angle and distant readings taken with lines of force N-S, E-W, Vert. Instrument passed the test; no failure in readings. | Instrument tested in same manner as Geod. 440. Passed the test; no failure in readings. |

## FIELD OPERATIONAL AND ENVIRONMENTAL EVALUATION

## (AISI)

## OPERATIONAL AND ENVIRONMENTAL TESTING

### RELIABILITY TESTS

Both AISI systems were subjected to a Mean-Time-Between-Failure (MTBF) series of tests and a continuous Electronic Cycling test as defined in O/E/S Test Plan, Volume II, Topic 1, buff pages, paragraph XXXV. The MTBF tests were conducted in the open, on a plot of ground adjacent to the contractor's plant. The Electronic Cycling tests were performed by a certified testing laboratory under the supervision of the contractor. The test methodology and results follow.

### MEAN-TIME-BETWEEN FA RE

These AISI 20-mission r. .bility tests consisted of 10 cycles of the following profile:

a. Start with the equipment packed for transport.

b. Unpack and set-up the equipment for operation over a known baseline.

c. Perform 10 readings.

d. Dismantle the equipment and repack for transport.

e. Perform manual transport function for not less than 5 feet and return to original position.

A known baseline, figure 10, was layed-out and staked by a registered professional land surveyor and utilized for the MTBF testing. The reliability checks were made by sighting on two of the three staked targets, A, B, and C, from each of the traverse points: #1 and #2, which were more than 5 feet apart. Sightings were made to two of the targets from each traverse point on an alternate basis:

OPERATIONAL ENVIRONMENTAL EVALUATION

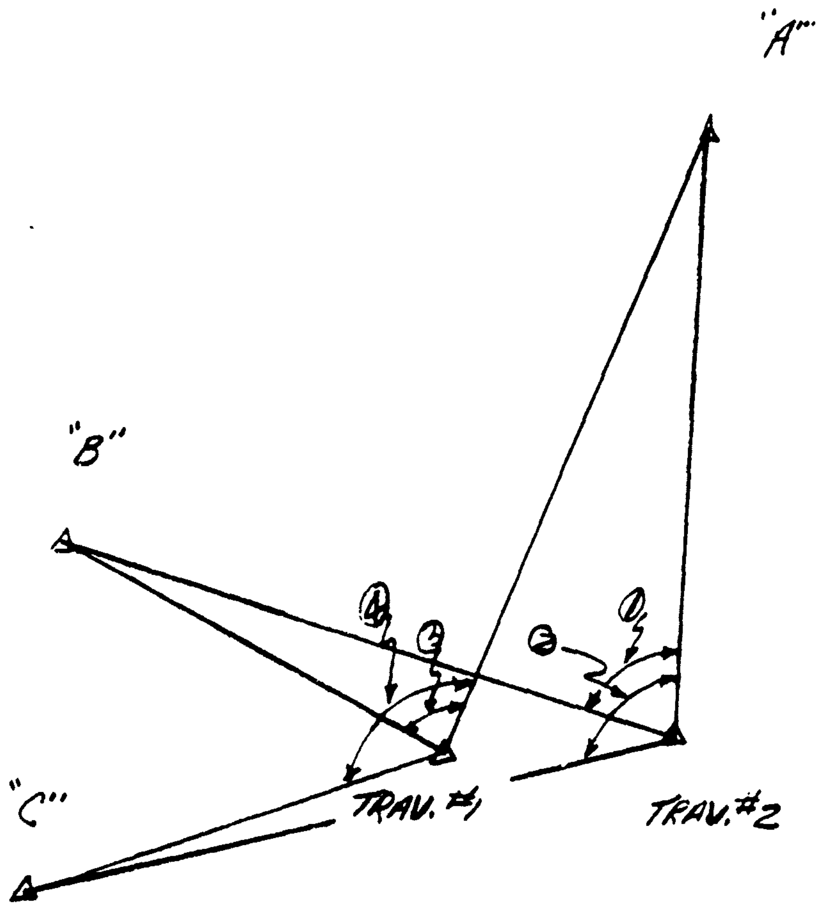
(AISI)

⊼ @ Δ#2 B.S. "A" 00 00 00 D= 109.26

| | | | | | |
|---|---|---|---|---|---|
| "B" | 1 | 310 | 06 | 04 | 74.48 |
| "C" | 2 | 264 | 45 | 48 | 56.53 |

⊼ @ Δ#1 B.S. "A" 00 00 00 D= 107.92

| | | | | | |
|---|---|---|---|---|---|
| "B" | 3 | 309 | 10 | 46 | 67.41 |
| "C" | 4 | 257 | 42 | 30 | 48.66 |




**RELIABILITY SYSTEM TEST TRAVERSE**

**FIGURE 10**

e.g. sight on A, then sight on B; sight on A, sight on C. Proper mechanical AISI functioning and identical electronic distance measurements were considered basic proof of reliable operation. After each 10 readings the AISI units were packed and moved from one traverse-point to the other thus performing the transport function.

Each series of tests was accomplished by three professional draftsmen who never had any experience with either total station surveying or electronic distance measuring equipment. During this test phase each of the men operated both the T2000 and System 440 AISI units. After each 10-reading cycle the AISIs were packed, moved at least 5 feet (from traverse point #1 to #2 and vice versa), unpacked, and set-up for operation. This procedure was followed precisely for a total of 2,060 individual readings.

Previous to the data gathering for reliability (MTBF), each of the men was given one half day's training with both AISI instruments. This consisted of individual AISI operation for angle, distance, and slope measurements, auxiliary battery hookup and operation, and instruction manual familiarization. There was no need for further instruction.

## ELECTRONIC CYCLING

The Electronic cycling tests were conducted for both the model T2000 and System 440 AISI total station units. Test procedures were governed by the requirements of paragraph XXXV, reliability of, O/E/S Test Plan, (Volume II, Topic 1, buff pages). In order to have uninterrupted testing, it was necessary to design and construct two individual fixtures, one for each AISI unit, to perform the mandatory automatic sequencing operations, during the consecutive seven day (168 hour) test.

The fixtures were attached to the body of each AISI unit and incorporated electric solenoids specially positioned over the keyboard in order to activate the necessary buttons in the correct sequence. Sequential operation was controlled by an electronic rotary programmer.

Some difficulty was experienced in setting up the AISIs due to the peculiarity of the electronic systems. In the case of the System 440, it would turn itself off after making the distance measurements. In a like fashion the T2000 would revert back to a save-energy mode and shut itself down. In order to overcome these shutdown modes it was essential that the sequential operation in Figure 11 be implemented.

The AISIs were placed simultaneously in an environmental chamber at 13 degrees C. External 12v power was utilized by both AISIs during the entire test period. As required by paragraph XXXV, reliability, the testing was cyclical in nature and consisted of a repetitive cycle set of 10 minutes duration as follows:

<u>Summary of Cycling</u>

1. Turn AISIs on
2. Press buttons as shown in Figure 11.
3. AISIs programmed for 9 minutes and 30 seconds of readings
4. AISIs shutdown for 30 seconds (10 minutes elapsed time)
5. AISIs started again automatically for a repeat cycle of 10 minutes
6. Repeat cycle for 168 hours

When the AISIs were placed in the environmental chamber, individual prism targets were placed at the chamber walls and used for measurement purposes. The prisms were each aligned and a test recording of the distance obtained. Once the individual AISI distance measurements were repeatable, the reliability testing began.

As the testing proceeded, measurement distances on the AISI panels were observed and recorded once every hour during the day time, and as available during the evening and early morning. Continuous repetitive individual readings confirmed proper operation. The planned period of testing, measuring, and recording then continued unabated for 168 hours (7 days).

**AISI RELIABILITY TEST FUNCTION PROCEDURES**

Consecutive functions necessary to commit each AISI instrument to recycling measurement operation.

## GEODIMETER

Consecutive Functions

Switch ON

Press F
Press 22
Press Enter
Press 0
Press Enter
* (PPM) Press Enter
**(OFFSET) Press Enter
***(HA) Press Enter
Press TRK
Press A/M

Switch OFF

## WILD

Consecutive Functions

ON

Set
Mode
9
5
Run
1
Run
Rep
Dist

OFF

*Parts Per Million Error
**Alignment OFFSET
***Horizontal Angle

FIGURE 11

## FIELD OPERATIONAL AND ENVIRONMENTAL EVALUATION

## (AISI)

## ISSUES AND QUESTIONS

These issues have been taken from various affiliated Army reports. In order to make referencing easy, each issue is listed by its original notation. Specifically, the origin of the issues is as follows:

| ISSUES | DOCUMENT | SOURCE | PAGES |
|---|---|---|---|
| 13.3.1 - 13.3.12 | TECOM IEP - SEPT 87 | VOLUME II, TOPIC 2 | WHITE |
| 6.1 - 6.8 | TECOM IEP - SEPT 87 | VOLUME II, TOPIC 2 | WHITE |
| 7.1 - 7.4 | TECOM IEP - SEPT 87 | VOLUME II, TOPIC 2 | WHITE |
| 2.0 - 2.2.8.2 | USAES IEP - AUG 87 | VOLUME II, TOPIC 6 | BLUE |
| T-1 - T-12 | BRDEC TEMP - JUNE 87 | VOLUME II, TOPIC 3 | YELLOW |
| 0-1 - 0-9 | BRDEC TEMP - JUNE 87 | VOLUME II, TOPIC 3 | YELLOW |

## TEST AND EVALUATION COMMAND

## (TECOM)

## INDEPENDENT EVALUATION PLAN ISSUES AND ANSWERS

13.3.1 Does AISI meet the performance requirements for topographic and construction surveys as specified in the AISI O&O Plan and the Topographic Support System ROC, during day and night operations? The following characteristics will be included:

a. Minimum and maximum range

b. Horizontal, slope, and zenith distance measurement accuracy

c. Horizontal and vertical angle measuring accuracy

d. Optical capabilities

13.3.1.1 Criteria

a. The AISI is required to perform the following mission profile: To provide horizontal coordinates, elevations, azimuths, and hard copy output using field survey methods at the accuracy required for accomplishing the theater geodetic, topographic, construction, and artillery and fire missions.

b. AISI equipment must have illuminated reticle for night observations.

c. Topographic characteristics desired are as follows:

(1) Distance measuring capabilities: range of from 2 meters to 14 km (O&O is expected to change to 7 km) with modular capability to 20 km and with a digital output of 1 mm with an accuracy of +/-5 mm and +3 ppm.

**Distance measuring requirements have been changed to 2 m to 7 km range with no modular capability extension. The evaluation conducted disclosed that both systems can measure distances starting with the prism against the instrument. However the Wild system telescope does not focus at less than 1.7 meters and the Geodimeter telescope does not focus at less than 1.7 meters. The Wild system measured 7099.629 meters SD using 8 prisms. Refer to Appendix J9 for field data. Initially the Geodimeter system would not measure 7 km using the prescribed prism count, but did measure the distance with 16 prisms. The manufacturer subsequently determined that defective internal components had been used, which in some cases caused stabilization at about 60% operating capacity. The manufacturer called in the defective equipment, and provided a new instrument for evaluation. It measured 7099.640 meters SD using 8 prisms. Refer to Appendix J9 for field data.**

**The digital output of both systems is to the 3rd decimal place when in the active measure mode, and thus measures to 1 mm.**

**The accuracy of both systems fall within the ± 5mm +3ppm requirement. Refer to Appendix J1 for field data.**

(2) Tracking mode with a response time of 1 second or less.

**In the tracking mode the Wild averaged 1.328 seconds per measurement. The Geodimeter averaged 1.075 seconds per measurement. Refer to Appendix J10 for field data.**

(3) Angle-measuring accuracy: electronic incremental reading of horizontal and vertical readout with an accuracy of 1.0 seconds with a measuring time of less than 0.5 second.

**The angular readings of the systems are incremental in nature and may be put into either sexagesimal or decimal readings depending on desired output. The standard error of the Wild system was found to be ±1.074" in the horizontal mode and ±0.636" for the vertical mode. The standard error of the Geodimeter system was found to be ±1.488" in horizontal and ±1.02" in vertical. Measuring time was determined on the basis of having turned the angle and sighted on the target prism to starting measuring time. This was successful for the Wild system and the time to measure in single mode was determined to be 0.8 second with continuous update approximately every 0.4 seconds. The Geodimeter reads on a continuous basis and therefore when you turn an angle and sight the target, the angular reading is available. To record, the REC button must be pushed. This process takes approximately six seconds. Refer to J10 for field data.**

(4) Optical capabilities: illuminated reticle for night observations; telescopic magnification of 30 to 40 power erect image for angle measurements; minimum focus of 2 meters or less for angle measurements.

**Both systems have illumination for night operation and was demonstrated by their use in making star shots. All images observed were erect. The telescope magnification was not determined.**

d. Construction Survey Capabilities. The construction device should have the same capabilities as the topographic device with the following exceptions:

(1) Range: from 2 meters to 2 km with a digital output in feet or meters readable to 1 mm or 0.005 foot.

**Reference 13.3.1.1.c(1). Also output can be shown in feet or meters.**

(2) Angle measurement: electronic incremental reading of horizontal and vertical readout with an accuracy of 30 seconds with a measurement time of less than 0.5 second.

**Reference 13.3.1.1.c(3)**

13.3.2 Does AISI meet the mission requirements for operation, storage, and transportation in all the expected environments, including nuclear high altitude electromagnetic pulse (EMP) and can the AISI be decontaminated?

13.3.2.1 Criteria

a. Ambient temperature range of -5 Deg F to 120 Deg F.

**The two systems were subjected to temperature extremes ranging from -5 degrees F to + 122 degrees F with no adverse effect on the operation of either unit. It was not possible in ambient temperatures existent in the evaluation area to reach these temperatures so they were generated in laboratory environments. Refer to the environmental evaluation report for temperature extreme data; Volume II, Topic 4, pink pages.**

b. The AISI will be expected to be used in the Hot, Basic, and Cold climatic design types as defined by AR 70-38, Table 2-1, and MIL-STD-210B.

Refer to "a" above, and to same environmental evaluation report.

c. The AISI will have the same transportability characteristics as present transportable (mobile) survey instruments. Field parties normally use 5/4-ton CUCV vehicles, 1/4-ton trucks, and 5-ton tractor vehicles for conducting surveying operations.

Military vehicles were not available to evaluate transportability requirements; however, the equipment was subjected to transport type vibration, and drop test to determine its performance for survivability. It was determined that the instruments outside of there carrying cases will not survive transport unless special precautions are taken. In their transport cases during tests they survived all transport type vibration and drop testing, although the Wild system EDM mounting adapter was damaged because the EDM was left attached during the drop tests. On-site corrective action consisting of removing two small metal burrs with emery cloth cleared the problem. Contact with the manufacturer disclosed that a positive locking system had been developed for the pincher type mounting of the EDM to the telescope which should eliminate or significantly reduce the potential for damage if dropped with the EDM mounted on the telescope. Additionally, the instruments were transported in commercial vans to and from the evaluation site, and, to and from the environmental test site. Travel to and from the evaluation site was approximately 50 miles round trip. An average of two trips per week were made for a period of 8 weeks for a total transport of 800 miles. Travel was on highway approximately 95% of the distance and an unimproved surface the remainder. The travel to and from the environmental test site was approximately 110 miles round trip, and was all highway travel. No instrument damage or

deterioration occured. It should be noted that the support item such as tripods, stakes, tapes and other equipment will not change with the introduction of the AISI.

13.3.3 Are the measured data automatically calculated, displayed, stored, and available for transfer and is the AISI compatible with software and external microprocessors for further production of survey functions?

13.3.3.1 Criteria

a. Calculation functions:

(i) Automatically performs horizontal and vertical angle measurements, horizontal distance measurement, and slope and zenith distance measurements.

The systems do not automatically perform angular measurements, but rather automatically read and display angular measurements once the operator has determined that proper angle turning and target sighting has been accomplished. The operator must cause the measurement to be taken and recorded. The same is true for distance measurement. No measurement can be taken and recorded until the target has been correctly sighted and the operator causes the function to be accomplished. Both systems can perform either horizontal or slope distance measurements. If slope distance is desired, the reading is taken and displayed on the instrument panel. For horizontal distance, the reading was taken as slope distance and reduced to horizontal prior to display. To obtain horizontal distance, certain basic data such as occupied point elevation, height of instrument and height of target must be entered to allow calculation. Zenith distance can be measured without special attachments by setting the vertical circle reading to zero (vertical)

**then rotating the telescope until the target is sighted, and then reading the vertical arc circumscribed. It must be noted that the tilt up/down for the Geodimeter is in degrees +40/-70 (with elbow +55/-75) and the Wild is +48/-55(+90/-55)).**

(2) Preprogrammed field calculations and storage.

**The intent of the criteria is not clear but neither instrument allows the entry of user developed programs into the instrument itself (i.e. a program to do a horizontal curve cannot be entered into instrument memory and called up for use in the field). There are routines available in the instrument to which data can be fed from the data collector (e.g. stakeout). The data collectors may be user programed to perform limited field calculations.**

(3) Built-in corrections for curvature, refraction, and slope.

**Both instruments contain automatic corrective factors for curvature and refraction. In addition, the instruments have distance corrective factors for atmospheric and prism affect. For the atmosphere, the Wild system has corrective factors from -999/+999 ppm while the Geodimeter has -60/+195. For prism effect, the Wild has -99/+99 while the Geodimeter has -999/+999 ppm. Both instruments display distance in horizontal measure if set for that mode. The verticle measurement is taken as slope and reduced before display.**

(4) Ability to compensate for eccentricity of the instrument.

b. Data storage and display functions:

(1) 60-kilobyte memory.

(2) Alphanumeric keyboard.

Both systems have alphanumeric keyboards. Refer to photographs, figures 2 and 5. The Wild system is a through mode keyboard that has its functions coded by color keyed to the function key that establishes the mode.

(3) 16-column display.

The instruments have display functions as follows:

(a) Wild - A through window display that uses one of the windows for informational purposes and two of the windows for data display. If horizontal and vertical angles are required, the distance is then displayed on the EDM screen. The data display has 7 columns/windows.

(b) The Geodimeter data display is a three line single window display. Because the EDM is integral, the distance is displayed with the angular measurements. The display area has 16 columns/lines.

(4) Minimum operating time of 16 hours.

The operating time of each system is dependent on usage and which battery of those available that is being used. The on board battery in each case is used as a basis for comparison. The batteries are rated at 2 amp-hours each. This gives a reading capability of about 400 points. This capability was not evaluated in the field, as no 400 shot program was attempted. During the reliability check evaluation it was found that the batteries would not last for 400 readings. The question of possible "memory set" in the batteries must be considered because the batteries had repeatedly been run through cycles of less than full discharge to full charge prior to the reliability check.

(5) Data storage and retention of 1,500 hours.

Both instruments have the capability of data storage and retention. The time that this capability will function was not evaluated because of the length of the required memory. However, the type used should clearly meet this requirement. The bubble memory, which the instruments contain, does not go blank when power is turned off. The exact period of time they retain memory is not known, but they are used in light weight portable computers when a disk drive would be too bulky or too fragile. It is not unreasonable for the memory to hold for 1500 clock hours. It should be noted that this is a 62.5 day period and present practice would preclude giving such a long period of time without transferring the data to a permanent media such as a disk storage.

(6) Direct data recording and dumping.

The exact measuring of these criteria is not clear, but data read are recorded when read. The data can either be stored in the instrument or in the

data recorder. The data can be transferred from the instrument into a computer directly. Both systems contain programs that will accomplish this data transfer.

(7) Ability to store and lay out precomputed distances.

As part of manufacturers software, it is possible to calculate distances on the computer and then transfer these distance calculations to the instrument for layout in the field. The same process can be accomplished by interfacing through the data collector.

(8) Ability to lay out precomputed right/left deflection angles.

As in 7 above, the right/left deflection angles for a curve can be computed and transferred electronically to the instrument for layout in the field. Refer to Appendix J3 for the calculated curve and the deflection angles. These angles were then transferred to the instrument and laid out.

(9) Capable of measuring and layout of vertical angles, zenith distance, and percent of slope.

Verticle angles can be measured as evidenced by the traverse run. As with horizontal angles and distances, vertical angles can be precomputed and transferred for layout.

Zenith distance can be measured on the Wild system using a right angle eyepiece, while the Geodimeter system can measure because it reads angles continuously and can therefore be set to a 180 degree reading by observing the vertical angle readout.

The percent slope capability is not a direct function. This capability is achieved through normal elevation, slope distance and horizontal distance calculation.

(10) LCD display readable in daylight or dark.

**Both systems have LCD displays that can be read in daylight. At night both systems have light illumination on the display windows. The light intensity can be adjusted to accommodate ambient light conditions or to control the visibility of the light in restricted conditions.**

c. Data transfer and compatibility with microprocessors and software designed for processing of surveying functions:

- RS232/V24 interface to computer system.

**Data were read into the data collector and then transferred to the computer. Refer to Appendices J5, J6, & J12 for examples of the data. The interface is through the RS232 port on the computer, and the connectors on the instruments/ data collectors.**

13.3.4 Do the available microprocessors, software, and peripheral equipment interface with AISI to provide the required printouts and plots of surveying functions?

13.3.4.1 Criteria

a. AISI will require the availability of a microcomputer, printer, minimum 24-inch wide drum plotter (multi-pen), and modules of software data reduction and processing routines for Construction and Topographic survey products. These necessary support peripherals will be located at existing central reduction facilities for use by multiple AISI users. AISI software must be compatible with both the

AISI and with the peripheral equipment. AISI peripherals and accessories should be introduced into the equipment inventory to support AISI in the same manner and at the same time AISI becomes part of the inventory, and be subject to the same evaluation and training requirements as AISI.

(1) External microprocessor capabilities.

- Fully MS/DOS compatible with AISI and other peripherals.
- Direct interface with the data storage device.
- Direct interface to a printer and plotter.
- Must be fully compatible with microprocessor.
- Software package shall consist of a full range of available, AISI compatible geodetic, topographic, and construction engineering programs.

**External microprocessor (computers).**

**The software packages used during the evaluation were MS-DOS compatible. This is evidenced by the fact that the software was run on IBM compatible machines which use the MicroSoft Disk Operating System as the machine operating system. The peripherals used were a Panasonic printer and a Nicolet plotter. No problem in interface with the computer software was surfaced.**

**The instruments for both systems hook directly to the data collector through the use of cables. The data collector, when disconnected from the instrument, connects directly to the computer through the use of cables. The computer is connected to the printer and plotter through normal cable hookups. In the case of the set-up used for evaluation, an A-B switch box was used to allow the maintenance of cable hookup with accessibility to either printer or plotter are required. No problems with compatibility of software or hardware were encountered. Data transfer from instrument to data collector to computer and**

**reverse were accomplished without difficulty. The software packages used contained routiues for use in geodetic, topographic and construction tasks. These were for evaluation only but demonstrate the fact that through proper software selection, required tasks can be performed using the available programs.**

(2) Plotter characteristics.

- Must be fully compatible with microprocessor.
- Must work with a minimum size format of 24 by 30 inches.
- Should have a multi-pen capability for different colors and pen sizes.

Plotter characteristics.

**The Nicolet plotter used in the evaluation was compatible with the computer used. Refer to informational plots in Appendix J12A for plotter output. The plotter evaluated can work at 24 x 30 inches, although that capability was not activated during the evaluation. The plotter used during evaluation had multiple capability which allows different color at different line weight selection.**

13.3.5 Does the AISI meet the established reliability requirements and, if not, what impact will this have on mission requirements?

13.3.5.1 Criteria

a. Quantitative reliability requirements will be established and included when the RAM Rationale Report (RRR) is completed. However, the AISI must have a high probability of completing the following mission requirements:

(1) The topographic surveyor furnishes field artillery weapons positioning and azimuth control on a continuing basis 12 hours per day, 7 days per week during wartime operation. Peacetime duties normally consist of solidifying and densifying control as needed for 10 hours per day, 5 days per week.

**The criteria for the topographic surveyor output was not evaluated, however, given the capability of the instrument and the lack of failures during the evaluation it appears probable that mission performance would be at a very high level of reliability. The problem of having sufficient batteries to operate on such a schedule is considered operational and not system related. Each system accumulated some 450 hours of time (18.75 days) in operation. The time in operation is considered to be that time in which power was applied to the instrument.**

(2) Construction surveyors in wartime run route reconnaissance, surveying bridges, roads, airfields, culverts, etc., for 12 hour days, 7 day weeks. During peacetime operations, the only difference is that the time is shortened to 10 hour days and 5 day weeks.

**The same rationale that applied to topographic requirements from a reliability standpoint also apply to construction survey tasks.**

13.3.6 Does the logistics supportability plan for the AISI system (AISI with support equipment and software) satisfy mission needs and what is the impact on the overall logistics supportability if any of the elements listed below are not met?

**The maintenance concept proposes that contractor support would be required to maintain and repair the system(s) selected for use by the military. Based on information provided by the manufacturer there are world wide networks of support that would be available to users of the systems under evaluation. Given that a**

support structure operated by manufacturers exists to support commercially used instruments in various locations of the world, it should not be difficult to receive support for similar instruments used by the military.

Should the decision be made that the military will support the equipment through its own maintenance and supply system, then initial stockage of repair parts would have to be based on manufacturers' recommendations with the normal development of technical manuals and logistical data base information being accomplished as part of the acquisition process. Given the world wide use of the systems evaluated and the past record of the manufacturers, the availability of support appears to be fairly certain.

13.3.6.1 End Item Requirement

a. Criteria.

(1) The operation and maintenance (whatever level required) must be performed by military personnel without contractor support. The maintenance ratio will be no more than 0.05.

(2) The operators will be able to service the AISI in 15-30 minutes.

Military personnel were not used in the evaluation except as observers. The observers were allowed to use the instruments to develop a feel for them. The maintenance ratio of .05 (3 min per hour of operation) was met during the evaluation, as no problems requiring maintenance actions were encountered. The equipment was operated in temperatures reaching 90+ degrees F, in rain showers, in high humidity and in temperatures in the 45-50 degree F range.

13.3.6.2 Supply Support

a. Criteria.

(1) Repair parts will be authorized in adequate quantities and diversity at the appropriate maintenance levels.

**No repair parts were used during the evaluation.**

(2) Repair parts will be consistent with the Maintenance Allocation Chart (MAC), Repair Parts and Special Tools List (RPSTL), and skills required to install and align parts.

**No MAC, RPSTL or skilled military personnel were used during the evaluation.**

13.3.6.3 Technical Data/Equipment Publications

a. Criteria.

(1) The technical data/equipment publications shall adequately reflect the system they support.

**No military formatted technical publications were available for use during the evaluation. Commercial operator and very limited maintenance manuals were used. The commercial operator manuals were considered to be inadequate for use by military personnel. The Wild manual was particularly bad in its fragmentation of information, because it attempted to cover several models and configurations and did not do justice to any. Its use required excessive page "flipping" and referencing from one section to another. A series of three "green cards" supplied with the**

system were the most helpful technical documentation provided. Geodimeter publications were less complex and tended to follow orderly procedural steps, but were still confusing and somewhat difficult to understand in some areas. Geodimeter's use of illustrations as part of the procedural steps was good. Geodimeter provided no maintenance instructions, however, except battery change information.

(2) The technical data/equipment publications shall be easily and completely understood by the maintenance personnel to whom they are addressed.

Not evaluated.

13.3.6.4 Support and Test Equipment

a. Criteria.

(1) The special/common tools, and support and test equipment shall be necessary and adequate for the performance of all authorized maintenance tasks at each level of maintenance.

No evaluation of tool and test equipment was conducted. The Wild system provides an allen wrench to allow alignment of the EDM and telescope axis when required, and one phillips screwdriver for other uses. The Geodimeter comes with no tools.

(2) The design of the system should permit the use of common tools whenever possible.

During the evaluation no apparent design features requiring the use of any tools. However, the internal components of the instruments were not observed.

13.3.6.5 Manpower and Personnel, Training and Training Devices

a. Criteria.

(1) The skill levels shall be appropriate for maintenance.

**No maintenance concept was made available, therefore evaluation of this criteria was not done.**

(2) The number of personnel shall be adequate for maintenance.

**See above.**

(3) The training provided shall be sufficient to impart the necessary skills for maintenance.

**See above.**

13.3.6.6 Transportation and Handling

a. Criteria. The AISI shall have the same transportability requirements as the current mobile survey equipment.

**The instruments were subjected to transportability and handling test criteria as a part of the environmental test program. In addition, the systems were transported by commercial van to and from the evaluation site. Refer to environmental test report, Volume II, Topic 4, pink pages, for transportability and handling test results.**

13.3.7 Can the AISI meet MANPRINT requirements (elements of HFE, RAM, ILS, New Equipment Training (NET), and personnel safety/health hazard) when operated and maintained by MOS-qualified, NET-trained, experienced personnel wearing clothing and equipment appropriate for the operating and maintenance environmental conditions?

13.3.7.1 Criteria

a. LCD display readable in daylight or dark.

**The LCD display is readable in daylight although strong direct sunlight, may at a given time, cause minor difficulty in seeing the display. For use during hours of darkness, the instruments have adjustable intensity illumination available for LCD reading.**

b. Illuminated reticle for night observations.

**Both systems have illuminated reticles for night observations.**

c. AISI, when used in the field data collection phase of operations, will be utilized by a crew of three topographic surveyors (MOS 82D) or construction surveyors (MOS 82B) similar to current operations. When the AISI is used in the data reduction phase, only one person should be required for each 12-hour shift, as opposed to the five required to provide quality control and supervision for the manual processing of field data in a 24-hour time period of operations. The AISI will have systems, health assessment, and human factors evaluations as required.

**Field data collection was performed using a crew of two persons. However, the collection of data could be increased by the use of two rod men. Therefore, a crew of three would be acceptable and would require no change in organizational**

structure. The processing of data is a one person opération because only one can effectively utilize the computer. The advisability of putting one individed at a computer terminal for 12 hours of data processing was not evaluated but appears to be excessive based on other studies, relative to time versus productivity. Further inquiry into this area could seem reasonable.

d. Maintenance for the AISI will be totally conducted by the contractor personnel throughout the life cycle.

No comment.

e. All HFE data shall comply with MIL-STD-1472C (Reference 11) and any other applicable requirements documents. Manuals must be written in accordance with TOP 1-2-609 (IMAGES) (Reference 12).

Not evaluated.

f. The AISI shall comply with the human factors engineering program requirements of AR 602-1 and MIL-H-46855, and shall be designed in compliance with applicable environmental protection requirements of AR 200-2.

Manufacturers data indicate that the equipment operates in the infrared area, non-lasing area. The labeling and wording on the control panels on both instruments is abbreviated, but in terms that the operator is or will easily become accustomed to. The color coding on the Wild control panel is likewise simple once the operator becomes trained in its use. The keys on the control panels of both systems would be difficult to operate while wearing gloves as they are close together, and more than one key could be inadvertently pressed. The equipment is designed to perform specific functions in a particular manner. The layout of course and fine controls on the Geodimeter require the operator to shift hands from one

set of knobs to another, but does give a difference in size and feel to identify the controls. Weight of the systems' components are within the 5th - 95th female-male percentiles.

13.3.8 Have the safety and health hazards associated with AISI operation, maintenance, transportation, and storage been controlled to an acceptable level?

13.3.8.1 Criteria

a. The AISI shall comply with the system safety and health hazard program requirements of ARs 385-10, 385-16, 40-5, 40-10, and MIL-STD-882B (Reference 13).

The AISI systems as evaluated, presented no identifiable health or safety hazards in operation. The systems are commercial proprietary and therefore the internal design for maintenance purposes was not evaluated. The infrared EDM was not evaluated for power output. Review of the safety literature did not contain measurement parameters to be followed. The items are non-lasing by design.

b. The AISI shall not present uncontrolled, catastrophic, or critical residual safety or health hazards. Safety deficiencies, defined as Category IA, IB, IC, ID, IIA, IIB, IIC, and IIIA risks, shall be eliminated or controlled by design whenever feasible.

No evidence of uncontrolled, catastrophic or critical residual health or safety hazards was apparent during the evaluation.

c. The AISI design must comply with the intent of MIL-STD-454, requirement 1 (safety), for operator and maintainer safety.

c.

d. Ionizing radiation sources shall not be used without prior notification and approval. When use is necessary, the source(s) shall be controlled IAW regulatory and statutory requirements.

**Ionizing radiation sources are not used in the AISI evaluation.**

e. Non-ionizing radiation sources (e.g., laser or other directed energy device) used in design must be approved, and should not present a hazard to personnel during operation (e.g., eye-safe laser).

**The items under evaluation were not designed for military use, but are commercial items being adapted. The infrared EDMs are designed for use in the commercial environment and have not been classified as a safety hazard.**

13.3.9 Does the AISI meet the MIL-STD-461B requirements for electromagnetic interference/electromagnetic compatibility?

13.3.9.1 Criterion

The electromagnetic interference emission and susceptibility characteristics shall conform to MIL-STD-461B, methods RE02 for radiated and CE03 for conducted tests, for Class B equipment. The frequency spectrum shall be from 0.014 through 1 GHz during the radiated tests and from 0.020 through 50 MHz during the conducted tests

with the following exceptions: (a) broadband radiated emissions (RE02) at 0.3 MHz and 0.7 MHz shall be increased by 5 dB and, (b) broadband radiated emissions (RE02) at 150 MHz shall be increased 6 dB above the requirements of MIL-STD-461B, as specified for similar type equipment such as SEDME.

**Refer to EMI test, a part of the environmental test report, Volume II, Topic 4, pink pages. Neither system passed the RE02 test. Request has been made to the manufacturers questioning what the problem might be and how it could be corrected. No response has been received to date. During the evaluation, commercial FM radios operating the frequency range of 14 Kilohertz to 10 Gigihertz were used in close proximity to the units (3-5 feet) with no discernible impact.**

13.3.10 Does AISI meet the physical design characteristics such as weight, size, and rigidity?

13.3.10.1 Criteria

a. Commercially available shapes are acceptable. Maximum weight of the total system has not been determined at this point in time. However, the maximum weight of each package shall not exceed the maximum safe lifting requirements for personnel as required by MIL-STD-1472C.

The pound weight breakdown of the AISI components is as follows:

| Component | Wild | Geodimeter |
|---|---|---|
| Instrument with battery | 24.155 | 15.420 |
| Instrument with EDM | 26.513 | 15.420* |
| Instrument with case | 32.720 | 19.145 |
| Data Collector | 1.980 | 1.295 |
| Single Prism | 0.370 | 0.475 |
| Prism Pole | 2.085 | 3.105 |
| EDM | 4.295 | ——— |
| 2 Amp Hr Battery | 2.000 | 2.140 |
| 7 Amp Hr Battery | 6.600 | 5.540** |
| Multi Prism with holder | 11.870 | 6.285 |
| Multi Prism Case | 7.985 | 6.280 |
| Tripod (Army issue) | *** | *** |
| Tribrach | 1.910 | 1.950 |

* Integral EDM

** 6 Ampere Hour

*** Standard straight leg, 12.500; adjustable leg, 15.000-16.000.

b. AISI design should include the following characteristics:

(1) Built-in corrections for curvature, refraction, and slope.

**Both systems have built in corrections for curvature, refraction and slope.**

(2) An electronic compensator for mislevel of the instrument.

**Both systems have a built in compensator for mislevel. The Wild compensator has a working range of > ±10' with a setting accuracy of < ±0.1". The Geodimeter compensator has a working range of ±8'.**

(3) Ability to compensate for eccentricity of the instrument.

**Both systems have the capability to store collimation and vertical index corrections after direct and reverse readings.**

(4) Impact-resistant carrying case and instrument test and repair kit.

**The carrying cases survived the vibration of drop tests without damage. Refer to environmental test report, Volume II, Topic 4, pink pages. No instrument test and repair kit was available.**

(5) Optical plumbing device.

**The Wild system has a built-in optical plumb. The Geodimeter does not have a built in optical plumb but relies on the tribrach with built in optical plumb.**

(6) Capable of tilting to at least 100 percent slope (45 degrees) up and down.

**Both instruments do not have the capability to exceed ± 45° tilt from the horizontal. The Wild telescope tilt range is +48°/-55°. The Geodimeter range is +40°/-70°.**

13.3.11 Is the electric power source acceptable for reliable AISI operation in compliance with the operational mode summary/mission profile?

13.3.11.1 Criteria

a. AISI must have a power source of both internal, rechargeable battery and external 12-volt dc vehicular battery.

**Both systems have onboard rechargable battery packs of 12 volts. The battery packs are removable and therefore can be interchanged for charging. Both systems have external rechargeable batteries of 7 amp hour capacity at 12 volts. Both systems provide cable connections to allow the use of vehicular power. However, both systems operate on 12 volts dc only.**

b. The external microprocessor should have a power supply of 110-220 volts ac with battery backup to prevent loss of data if primary power is interrupted.

**The computer used in the evaluation operates on 100 volts ac. It does not have a battery backup as a part of the computer. To achieve this, it would be necessary to use an uninterruptable power supply which will support the memory for approximately two hours. It also will allow the operator to perform a "save data" procedure.**

13.3.12 Is the AISI compatible with the Army Standard equipment that it is required to interface with?

13.3.12.1 Criteria

a. The AISI shall be compatible with the standard U.S. Army tripods and tribrachs.

**Standard issue tripods were obtained and used interchangeably to mount instruments and targets. Both systems' instruments were mounted on the tripods at various times. Tribrachs that came with each system were used interchangeably between systems and on all tripods.**

b. The AISI will use the Doppler Satellite Survey System and Global Positioning System for extension of prime control established with these systems. It will be used for alignment and updating position data of the Position and Azimuth Determining System and other Inertial Navigation Systems. The microprocessor will allow direct access to data base allowing for rapid dissemination of the information contained in them.

**No evaluation of the criteria was performed. The ability of the computer to access the data base for PADs or GPS is somewhat dependent on the data base format and the software available to the AISI computer.**

## 6. CRITICAL TECHNICAL EVALUATION ISSUES

6.1 Does AISI meet the performance requirements for topographic and construction surveys as specified in the AISI O&O Plan and the Topographic Support System ROC, during day and night operations? The following characteristics will be included:

a. Minimum and maximum range

**See response to issue 13.3.1**

b. Horizontal, slope, and zenith distance measurement accuracy

**See response to issue 13.3.1**

c. Horizontal and vertical angle measuring accuracy

**See response to issue 13.3.1.**

d. Optical capabilities

**See response to issue 13.3.1.**

6.2 Does AISI meet the mission requirements for operation, storage, and transportation in all the expected environments, including nuclear high altitude electromagnetic pulse (EMP) and can the AISI be decontaminated?

**See response to issue 13.3.2.**

6.3 Are the measured data automatically calculated, displayed, stored, and available for transfer and is the AISI compatible with software and external microprocessors for further production of survey functions?

**See response to issue 13.3.3.**

6.4 Do the available microprocessors, software, and peripheral equipment interface with AISI to provide the required printouts and plots of surveying functions?

**See response to issue 13.3.4.**

6.5 Does the AISI meet the established reliability requirements and, if not, what impact will this have on mission requirements?

**See response to issue 13.3.5.**

6.6 Does the logistics supportability plan for the AISI system (AISI with support equipment and software) satisfy mission needs and what is the impact on the overall logistics supportability if any of the elements listed below are not met?

a. End-Item Requirements.

**See response to issue 13.3.6.**

b. Supply Support.

**See response to issue 13.3.6.**

c. Technical Data/Publications.

**See response to issue 13.3.6.**

d. Support and Test Equipment.

**See response to issue 13.3.6.**

e. Manpower and Personnel, Training and Training Devices.

**See response to issue 13.3.6.**

f. Transportation and Handling.

**See response to issue 13.3.6.**

6.7 Can the AISI meet MANPRINT requirements (elements of HFE, RAM, ILS, New Equipment Training (NET), and personnel safety/health hazard) when operated and maintained by MOS-qualified, NET-trained, experienced personnel wearing clothing

and equipment appropriate for the operating and maintenance environmental conditions?

**See response to issue 13.3.7.**

6.8 Have the safety and health hazards associated with AISI operation, maintenance, transportation, and storage been controlled to an acceptable level?

**See response to issue 13.3.8.**

## 7. OTHER TECHNICAL EVALUATION ISSUES

7.1 Does the AISI meet the MIL-STD-461B requirements for electromagnetic interference/electromagnetic compatibility?

**See response to issue 13.3.9.**

7.2 Does AISI meet the physical design characteristics such as weight, size, and rigidity?

**See response to issue 13.3.10.**

7.3 Is the electric power source acceptable for reliable AISI operation in compliance with the operational mode summary/mission profile?

**See response to issue 13.3.11.**

7.4 Is the AISI compatible with the Army Standard equipment with which it is required to interface?

**See response to issue 13.3.12.**

U.S. ARMY ENGINEER SCHOOL

INDEPENDENT EVALUATION PLAN ISSUES AND ANSWERS

2.0 Operational Issues and Criteria for the Automatic Integrated Survey Instrument (AISI):

2.1 Critical Evaluation Issues and Criteria:

2.1.1 Issue: Does the AISI effectively perform topographic and construction survey tasks in an operational environment?

**Yes. Refer to Appendices J3, J4, J5, J6, & J12.**

2.1.1.1 Scope: This issue will evaluate the capability of the candidate(s) to effectively perform topographic and construction survey tasks when employed by representative users IAW the operational mode summary/mission profile (OMS/MP). An assessment will be made of each candidate's demonstrated performance in climatic design types hot, basic, and cold, IAW AR 70-38. Testing will be conducted IAW the OMS/MP and test settings described in the test support package (TSP). Testing will be conducted in ambient weather conditions, during day and night/limited visibility conditions expected on the battlefield. Data collected will include the time required to complete tasks and the ease with which operator's performed required tasks. Data gathered will be used in a baseline comparison with current survey equipment.

2.1.1.2 Criteria:

2.1.1.2.1 The assigned crew using the AISI will perform the following tasks within the time and accuracy constraints specified 95% of the time.

## AISI TASK LIST

| TASK | | ACCURACY | TIME |
|---|---|---|---|
| 1. Preparation for movement | | N/A | 15 min |
| 2. Preparation for field operations (setup) | | | |
| a. Distance Measurement | | N/A | 5 min |
| b. Direction Measurement (horiz & vert) | | N/A | 8 min |
| 3. Conduct data collection | | | |
| a. Distances | | +/-5mm + 3ppm | 2 min |
| b. Directions (horiz & vert) | (Topo) | +/-1 sec | 10 min |
| | (Const) | +/-30 sec | 5 min |
| c. Layout curves (per point) | | +/-.0242 ft per 100 ft | 1 min |
| d. Planetabling (per point) | | +/-.0242 ft per 100 ft | 1 min |
| 4. Process field data | (Topo) position closure to at least 1:20,000 | | 3-5 min** |
| | (Const) position closure to at least 1: 5,000 | | 3-5 min** |

**Dependent upon number of stations in traverse scheme.

2.1.1.2.2 The AISI must be capable of operating, IAW the OMS/MP, on an internal rechargeable battery for up to 12 hours. It must also be capable of operating on an external 12 volt DC vehicular battery.

**Will not operate for 12 hours on internal (on board) battery if used on a continuous basis. Will operate on 12 volt battery only.**

2.1.2 Issue: Does the AISI provide adequate data transfer capability?

2.1.2.1 Scope: This issue will evaluate the capability of the candidate(s) to directly record measured data to their component data recorder when employed by representative users IAW the OMS/MP. This issue will also evaluate the capability to "dump" or transfer electronic data via a RS232/V24 interface to an external microprocessor. Additionally, information concerning the ability of representative users to transfer data from the microcomputer to the data recorder and use that data to perform survey layouts will also be collected.

2.1.2.2 Criteria:

2.1.2.2.1 The AISI, when employed by representative users will be able to record data to the data collector and transfer that data to the external microprocessor with 98% fidelity, 95% of the time.

**Refer to Appendices J3, J4, J5, J6, & J12.**

2.1.2.2.2 Representative users will be able to transfer data from the external microprocessor to the data recorder and with that data, use the AISI to layout precomputed distances and deflection with 98% fidelity, 95% of the time.

**Refer to Appendix J3.**

2.2 Non-Critical Evaluation Issue and Criteria:

2.2.1 Issue: Does the AISI demonstrate adequate RAM for operational mission requirements?

2.2.1.1 Scope: Data will be collected to determine the demonstrated RAM characteristics of each candidate and to identify potential availability and maintainability problems. Operational RAM characteristics will be evaluated as the system is exposed to a variety of environmental conditions while conducting operational missions IAW the OMS/MP. Reliability, maintainability, and logistic support data will be collected and analyzed, and the impact on system readiness objectives and/or operational availability ($A_o$) assessed. Maintenance data will include level of maintenance required and effectiveness of diagnostic procedures. Skills and manhours to accomplish the required maintenance tasks will be evaluated. Operational reliability in terms of mean time between operational mission failures will be scored using the failure definition/scoring criteria (FD/SC) (Appendix D), developed jointly by the combat developer, material developer, and independent evaluators (both technical and operational).

2.2.1.2 Criteria:

2.2.1.2.1 MCTBOMF for the AISI must equal or exceed 120 hours.

2.2.1.2.2 The maintenance ratio for the AISI will not exceed 0.4 maintenance manhours/hours of operation.

2.2.1.2.3 $A_o$ for the AISI will be TBD or greater.
(NOTE: RAM parameters will be furnished by USAES upon the approval of the RAM rationale.)

2.2.2 Issue: Are there any electronic capability problems associated with operation of AISI?

2.2.2.1 Scope: Data will be collected to determine the electronic characteristics of each candidate and to identify potential interference problems between the AISI and other electronic equipment projected for use in the same area. During testing, any incident of interference will be reported and analyzed to evaluate its impact on operation of AISI or other systems.

2.2.2.2 Criterion: The AISI shall not present any interference to other systems nor be susceptible to interference from other systems used in the same area of the battlefield.

**No discernable interference patterns were observed. Refer to electromagnetic test report; Volume II, Topic 4, pink pages. Normal radio usage presented no problems to or from the unit.**

2.2.3 Issue: Is the technical documentation for AISI accurate, comprehensive, and effective?

2.2.3.1 Scope: During testing, test players will be observed, while performing operator, maintainer, and supervisor tasks using commercial manuals. Accuracy, comprehensiveness, and effectiveness will be assessed. Comments will be provided in the following areas:

a. Portions of text that are not clear, comprehensive, concise, or accurate.

b. Portions of text that operators, maintainers, and supervisors cannot adequately use or that are unnecessary or inadequate.

2.2.3.2 Criteria:

2.2.3.2.1 The AISI technical documentation and other software must correctly describe each of the critical task requirements.

**The commerical manuals correctly describe the tasks but are difficult to use.**

2.2.3.2.2 Ninety-five percent of trained representative military users, using the technical documentation, will be able to perform 100% of the critical tasks.

**No trained military personnel took part in the evaluation.**

2.2.3.2.3 The Reading Grade Level (RGL) of all technical documentation and training manuals will be within ± one RGL for the particular MOS designated to operate/maintain the system.

**RGL not determined.**

2.2.4 Issue: Does the training program adequately prepare the representative soldier to use and maintain the AISI in an operational environment?

2.2.4.1 Scope: The evaluation of training support will be conducted during all phases of testing. The intent of the evaluation is to assess the training as outlined in the Individual and Collective Training Plan (ICTP), and as represented by the Training Test Support Package (TTSP), to train representative soldiers to establish performance standards. Pretest (pretraining) skills will be used as the baseline for assessing training effectiveness by a comparison to post-test skills. Source of tasks, conditions and standards identified in the ICTP will be used as the basis for the training evaluation. The entire training package will be assessed and trainer and tester input will be solicited to determine adequacy of training devices,

manuals, aids, and other material. Training aids or devices will be evaluated for their effectiveness and ability to influence training transfer. Individual performance will be assessed during normal conduct of the test. Tasks that players have particular difficulty with will be reported and the training program for those tasks, including the performance standards, will be reassessed. Tasks necessary for operation and maintenance that were omitted from the training plan will be reported.

2.2.4.2 Criterion: Upon completion of training, 95% of the representative soldiers will be able to perform all of the critical tasks identified in the TTSP to prescribed standards.

**Trained military personnel were not used in the evaluation.**

2.2.5 Issue: Is AISI designed for efficient and effective logistics support?

2.2.5.1 Scope: This issue is designed to assess the commercial end items for their logistical support requirements. Areas of consideration are packaging, handling and storage, facilities, supply/provisioning, standardization and interoperability. Effects of modularity on logistics and training will be assessed. Also, the logistical support hardware and software requirements for the system will be assessed. The adequacy and military availability of common and special tools, supporting test equipment, repair parts and maintenance facility requirements will be determined. Software elements assessed shall include technical manuals, repair parts and special tool list (RPSTL). maintenance allocation chart (MAC) and parts allocation chart (PAC). Logistical considerations of supply will be determined by the Integrated Logistic Support (ILS) Manager based on the approved basis-of-issue plan and the Materiel

Fielding Plan (MFP). The frequency and type of logistic-related test incidents will form the basis for subjectively assessing the adequacy of the logistic program.

2.2.5.2 Criteria:

2.2.5.2.1 Repair parts and warranties from the manufacturer will be specified and must support the system at all levels of maintenance.

**Not part of the evaluation.**

2.2.5.2.2 The supply and maintenance organization will be completely described and the responsibility and work flow for each level of supply and maintenance will be clearly defined in the MAC.

**Refer to paragraph 13.3.6**

2.2.5.2.3 Integrated logistical support responsibilities, including maintenance and supply will be allocated to the proper level consistent with existing supply and maintenance procedures as determined by TOE.

**Refer to paragraph 13.3.6**

2.2.5.2.4 Requirements for supply and maintenance facilities will be consistent with current Army facilities, capabilities, and allocations.

**Refer to paragraph 13.3.6**

2.2.6 Issue: Can the AISI be transported by all required modes?

2.2.6.1 Scope: This issue addresses the transportability characteristics of the AISI in assessing transport by various modes. Due to small size and weight, it is not

anticipated that the AISI will have transportability limitations. However, the ability of the AISI to withstand the rigors of transport must be answered. Additionally, the ability of the crew to transport the AISI, by vehicle and backpack must be evaluated.

2.2.6.2 Criteria:

2.2.6.2.1 AISI will be transportable within the using units existing TOE transportation capability.

2.2.6.2.2 The assigned crew will be able to properly package the AISI for transport.

2.2.6.2.3 The ruggedized carrying case will protect the AISI from damage during normal transport.

**Refer to environmental test report; Volume II, Topic 4, pink pages.**

2.2.6.2.4 The AISI will be man portable in its carrying case and be capable of being transported (backpacked) by the assigned crew.

**All cases have handles and are within weight limits. Both instrument cases are designed to be backpacked.**

2.2.7 Issue: Are there any safety or health hazards associated with the AISI?

2.2.7.1 Scope: This issue will address candidate items for the purpose of identifying and assessing safety and health hazards during all phases of testing to include storage, transport, maintenance and operation. All safety and health hazard discrepancies identified must be recorded and categorized IAW MIL-STD 882B.

2.2.7.2 Criteria:

2.2.7.2.1 The AISI will not contain any uncontrollable safety or health hazards.

**No safety or health hazards were observed.**

2.2.7.2.2 The AISI design will comply with applicable safety requirements IAW AR 385-10, 385-16, 40-5, 40-10, MIL-STD 454 and TB MED 524.

**A commercial product was used and presented no safety hazards.**

2.2.8 Issue: Is the AISI adequately designed with regard to sound human engineering and principles?

2.2.8.1 Scope: This issue addresses the design of candidate(s) with regard to human factors engineering principles when the system is employed in an operational environment by representative users. A trained government human factors engineer will observe testing and prepare a HFE assessment report which will be provided to the independent evaluators for input to the independent evaluation report (IER). Testers will report HFE problems as they occur.

2.2.8.2 Criteria:

2.2.8.2.1 The AISI shall meet the human factors engineering requirements of AR 602-1 and MIL-H 46855.

**Not evaluated IAW scope.**

2.2.8.2.2 Personnel must be able to transport, set-up, operate, and store the AISI in its carrying case while wearing cold weather clothing.

The instruments have buttons and knobs that may be difficult to operate precisely while being used by personnel wearing heavy gloves.

5. Critical T&E Issues and Criteria. The following T&E issues and criteria were derived from the required operational and technical characteristics contained in the O&O Plan and from the input provided by the operational and technical evaluators, USAES and TECOM respectively. Critical issues are identified with an asterisk; the others are noncritical. Compliance with critical issues and criteria will be demonstrated during the market investigation testing and from commercial AISI manufacturer's and customer's usage data. Any remaining noncritical issues will be answered during First Article Tests and/or Follow-on Test and Evaluation (FOT&E).

a. Technical Issues

*(T-1)Issue: Does the AISI meet the performance requirements for topographic and construction surveys as specified in the AISI O&O Plan and the Topographic Support System ROC, during day and night operations, to include the following characteristics:

a. Minimum and maximum range;

b. Horizontal, slope, and zenith distance measurement accuracy;

c. Horizontal, and vertical angle measuring accuracy;

d. Optical capabilities?

Criteria: The AISI is required to perform the following mission profile: To provide horizontal coordinates, elevations, azimuths, and hard copy output using file survey methods at the accuracy required for accomplishing the theater geodetic, topographic, construction, and artillery and fire missions.

**Refer to paragraph 13.3.1.**

Topographic characteristics desired are as follows:

a. Range of from 2 meters to 7 kilometers, with a digital output to 1 mm with an accuracy of +/-5mm and +3ppm.

b. Tracking mode with a response time of 1 second or less.

c. Electronic incremental reading of horizontal and vertical readout with an accuracy of 1.0 second with a measuring time of less than 0.5 second.

d. Illuminated reticle for night operations; telescopic magnification of 30 to 40 power erect image for angle measurements; minimum focus of 2 meters for less for angle measurements.

e. Tracking mode.

Construction survey characteristics. The construction AISI should have the same capabilities as the topographic AISI with the following exceptions:

a. Range: From 2 meters to 2 kilometers with a digital output in feet or meters readable to 1mm or .005 foot.

b. Angle measurement: Electronic incremental reading or horizontal and vertical readout with an accuracy of 30 seconds with a measurement time of less than 0.5 second.

*(T-2) Issue: Does AISI meet the mission requirements for operations, storage, and transportation in all the expected environments?

Criteria: The AISI will be expected to be used in the Hot, Basic, and Cold climatic design types as defined by AR 70-38, table 2-1, and MIL-STD-210B. The AISI will have the same transportability characteristics as present transportable (mobile) survey instruments. Field parties normally travel in 5/4 ton CUCV vehicles, survey company personnel 1/4 ton trucks, and the survey section of the Topographic Support System in a 5-ton tractor vehicle. AISI equipment should not be any more susceptible to military environmental conditions than currently fielded survey equipment.

**Refer to paragraph 13.3.3.**

*(T-3) Issue: Are the measured data automatically calculated, displayed, stored, and available for transfer and is the AISI compatible with software and external microprocessors for further production of survey functions?

**Refer to paragraph 13.3.3.**

Criteria: Calculation functions.

a. Automatically performs horizontal and vertical angle measurements, horizontal distance measurements, and slope and distance measurements.

b. Preprogrammed field calculations and storage.

c. Built in corrections for curvature, refraction, and slope.

d. Ability to compensate for eccentricity of the instrument.

Data storage and display functions:

e. 60 kilobyte memory.

f. Alphanumeric keyboard.

g. 16 column display.

h. Minimum operating time of 16 hours.

i. Direct data recording and dumping.

j. Ability to store and lay out precomputed distance.

k. Ability to lay out precomputed right/left defection angles.

l. Capable of measuring and layout of vertical angles, zenith distance, and percent of slope.

m. Direct data recording and dumping.

n. LCD display readable in daylight or dark.

Data transfer and compatibility with microprocessors and software designed for processing of surveying functions: RS232/V24 interface to computer system.

*(T-4) Issue: Do the available microprocessors, software, and peripheral equipment interface with AISI to provide the required printouts and plots of surveying functions?

**Refer to Appendices J2, J4, J5, J6, & J12.**

Criteria: External microprocessor capabilities:

a. Fully MS/DOS compatible with AISI and other peripherals.

b. Direct interface with the data storage device.

c. Direct interface to a printer and plotter.

d. Must be fully compatible with microprocessor.

e. Software package shall consist of a full range of available, AISI compatible geodetic, topographic, and construction engineering programs.

Plotter characteristics:

a. Must be fully compatible with microprocessor.

b. Must work with a minimum size format of 24 by 30 inches.

c. Should have a multipen capability for different colors and pen sizes.

*(T-5) Issues: Does the AISI meet the reliability requirements for the MTBF of at least 200 missions and at least 300 hours for continuous electronic cycling?

Criteria: The MTBF for the AISI must be at least 200 missions for the system and 300 hours for the continuous electronic cycling. The AISI reliability should be capable of performing the following mission requirements.

**Refer to Environmental Tests.**

a. The topographic surveyor in wartime furnishes the field artillery weapons positioning and azimuth control on a continuing basis 12 hours each day, 7 days a week. Peace time normally is solidifying and densifying control on an as needed basis 10 hour days and 5 day weeks.

b. Construction surveyors in wartime run route reconnaissance, surveying bridges, roads, airfields, culverts, etc., 12 hour days, 7 day weeks. During peace time operations, the only difference is the week is shortened to 10 hour days and 5 day weeks.

*(T-6) Issue: Does the logistic supportability plan for the AISI system (AISI with support equipment and software) satisfy mission needs and what is the impact on the overall logistics supportability if any of the elements listed below are not met?

**Refer to paragraph 13.3.6.**

a. End Item Requirements.

b. Supply Support.

c. Technical Data/publications.

d. Support and Test Equipment.

e. Manpower and Personnel, Training and Training Devices.

f. Transportation and Handling.

Criteria: The AISI, along with associated data reduction equipment, will be issued to each survey squad organic to the Engineer Topographic Battalion (TA), TOE 05-335H (05605L000), Engineer Survey Company, TOE 05-338H (05606L000), and Engineer Topographic and Intelligence Teams, TOE 05-540H31C (Survey Squad 05-540LB), and each survey element of the Construction Battalion TOE 05-116H. The peripherals required for computation, plotting, and printing of data will be issued as a separate set on a basis of one for every three AISI's issued, as required by the BOIP. The topographic survey squad is direct support (DS) to corps and general support (GS) at EAC.

AISI will reduce the number and type of existing survey instruments required by each survey squad, thus enabling the Army to replace the Wild T-2, degree reading, one second, Theodolites; the Surveying Equipment, Distance Measuring, Electronic, Medium Range (SEDME-MR); the theodolite survey, 0.2 second, with tripod and carrying case, (in part); the Alidade, surveying, with plane table and tripod; the target set, surveying; and the rod level philadelphia.

Repair parts will be authorized in adequate quantities and diversity at the appropriate maintenance levels. Repair parts will be consistent with the Maintenance Allocation Chart (MAC), Repair Parts and Special Tools List (RPSTL), and skills required to install and align parts.

The technical data/equipment publications shall adequately reflect the system they support. The technical data/equipment publications shall be easily and completely understood by maintenance personnel.

The special/common tools, and support and test equipment shall be necessary and adequate for the performance of all authorized maintenance tasks at each level of maintenance. The design of the system should permit the use of common tools whenever possible.

The skill levels shall be appropriate for maintenance. The number of personnel shall be adequate for maintenance. The training provided shall be sufficient to impart the necessary skills for maintenance. The operators will be able to service the AISI in 15-30 minutes.

Every effort will be made to ensure that the system will be supportable by the standard Army Logistics and Maintenance systems and will use standard tools and TMDE. However, the urgent operational needs necessitate that the system be fielded initially with commercial training literature and an operational readiness end item float. During this period, maintenance support will be provided by contract. A maintenance concept analysis will be conducted to determine whether support above organizational level using contacted resources is cost effective and responsive throughout the equipment life cycle. Maintenance, above operator levels, will be performed in the same manner as presently accomplished on Topographic/Field Artillery survey sophisticated electronic equipment, if the maintenance concept analysis determines it cost effective.

AISI will require the availability of a microcomputer, printer, plotter, and

modules of software data reduction and processing routines for Construction and Topographic survey products. These necessary support peripherals will be located at existing central reduction facilities for use by multiple AISI users. AISI software must be compatible with both the AISI and with the peripheral equipment. AISI peripherals and accessories should be introduced into the equipment inventory to support AISI in the same manner and at the same time AISI becomes part of the inventory, and be subject to the same evaluation and training requirements as AISI.

The AISI shall have the same transportability requirements as the current survey equipment.

*(T-7) Issue: Does the AISI meet the man-machine interface requirements of MIL-STD-1472 and are the human factors engineering design and operational characteristics adequate to enable MOS-82D, 41B, 35E qualified soldiers appropriately clothed for the environments of interest to permit effective operation and maintenance?

**The AISIs are commercial items designed to perform surveying tasks and are operated by a variety of personnel in all environments. Adequately trained soldiers should have no problems**

Criteria: The AISI when used in the field data collection phase of operations will be utilized by a crew of three topographic surveyors (MOS 82D) or construction surveyors (MOS 82B) similar to current operations. When the AISI is used in the data reduction phase, only one person should be required for each 12-hour shift, as opposed to the five personnel required to provide quality control and supervision for the manual processing of field data in a 24 hour time period of operations.

The AISI will have systems, health assessment, and human factors evaluations as required.

Maintenance personnel for the AISI will be Topographic Instrument Repair Specialist (MOS 41B) and the Special Electronic Devices Repairer (MOS 35E) as presently assigned to engineer topographic units and corps/division maintenance units.

All HFE data shall comply with MIL-STD-1472 and any other applicable requirements documents. The AISI shall comply with the human factors engineering program requirements of AR 602-1 and MIL-H-46855, and shall be designed in compliance with applicable environmental protection requirements of AR 200-2, and AR 200-2.

*(T-8) Issue: Have the safety and health hazards associated with AISI operation, maintenance, transportation, and storage been controlled to an acceptable level?

**No safety or health hazards were observed.**

Criteria: The AISI shall comply with the system safety and health hazard program requirements of ARs 385-10, 385-16, 40-5, 40-10, and MIL-STD-882B. The AISI shall not present uncontrolled, catastrophic, or critical residual safety or health hazards. Safety deficiencies, defined as Category IA, IB, IC, ID, IIA, IIB, IIC, and IIIA risks, shall be eliminated or controlled by design whenever feasible.

The AISI design must comply with the intent of MIL-STD-454, requirement 1 (safety), for operator and maintainer safety.

Ionizing radiation sources shall not be used without prior notification and approval. When use is necessary, the source(s) shall be controlled IAW regulatory and statutory requirements. Non-ionizing radiation sources (e.g., laser or other directed energy device) used in design must be approved, and should not present a hazard to personnel during operation (e.g., eye safe laser).

*(T-9) Issue: Does the AISI meet the MIL-STD-461B requirements for electromagnetic interference/electromagnetic compatibility?

**Refer to electromagnetic test report; Voiume II, Topic 4, pin'. pages.**

Criteria: The electromagnetic interference emission and susceptibility characteristics shall conform to MIL-STD-461, methods REO2 for radiated and CE03 for conducted tests, for Class B equipment. The frequency spectrum shall be from 0.014 through 1 GHz during the radiated test and from 0.020 through 50 MHz during the conducted tests with the following exceptions:

(a) Broadband radiated emissions (RE02) at 0.3 MHz and 0.7 MHz shall be increased by 5 dB and,

(b) Broadband radiated emissions (RE02) at 150 MHz shall be increase 6 dB above the requirements of MIL-STD-461. (SEDME Specification, MIL-STD-53046).

(T-10) Issue: Does AISI meet the physical design characteristics such as weight, size, and rigidity?

Criteria: Commercially available shapes are acceptable. As a guide for comparison with similar systems, the maximum weight of the distance meter, exclusive of tripods, but including primary power source shall not exceed 25 pound (11.3kg). The total system weight shall not exceed 50 pounds (22.7 kg) (SEDME letter Requirements)

**Refer to weight table paragraph 13.3.10.1.**

AISI design should include the following characteristic:

a. An electronic compensator for mislevel of the instrument.

b. Impact-resistant carrying case and instrument test and repair kit.

c. Capable of tilting to at least 100 percent slope (45 degrees) up and down.

(T-11) Issue: Is the electric power source acceptable for reliable AISI operation in compliance with the operational mode summary/mission profile?

Criteria: The AISI will operate from an internal, rechargeable battery and external 12 to 24 volt DC vehicular battery. The external microprocessor should have a power supply 110-220 volts AC with battery backup to prevent loss of data if primary power is interrupted.

**The systems use 12 volts. The computer did not have battery backup.**

(T-12) Issue: Is the AISI compatible with the Army Standard equipment that it is required to interface with?

Criteria: The AISI shall be compatible with the standard U.S. Army tripods and tribrachs. The AISI will use the Doppler Satellite Survey System and Global Positioning System for extension of prime control established with these systems. It will be used for alignment and updating position data of the Position and Azimuth Determine System and other Inertial Navigational Systems. The microprocessor will allow direct access to data bases allowing for rapid dissemination of the information contained in them.

**Standard tripods and tribrachs were used during the evaluation. No evaluation of outside database information access was conducted.**

b. Operational Issues

*(0-1) Issue: Does the AISI effectively perform topographic and construction survey tasks in an operational environment?

This issue will evaluate the capability of the AISI to effectively perform topographic and construction survey tasks when employed by representative users IAW the operational mode summary/mission profile (OMS/MP). An assessment will be made of the AISI's performance in climatic design types hot and basic IAW AR 70-38. Testing will be conducted IAW the OMS/MP and test settings described in the test support package (TSP). Testing will be conducted in ambient weather conditions, during day and night/limited visibility condition expected on the battlefield. Data gathered will be used in a baseline comparison with current survey equipment.

Criteria: The assigned crew using the AISI will perform the following tasks within the time and accuracy constraints specified 95% of the time:

**Refer to paragraph 2.1.**

| TASK | | ACCURACY | TIME |
|---|---|---|---|
| 1. Preparation for movement | | N/A | 15 min |
| 2. Preparation for field operation (setup) | | | |
| a. Distance Measurement | | N/A | 5 min |
| b. Direction Measurement (horiz & vert) | | N/A | 8 min |
| 3. Conduct data collection | | | |
| a. Distances | | +/5mm +3ppm | 2 min |
| b. Directions (horiz & vert) | (Topo) | +/-1 sec | 10 min |
| | (Const) | +/-30 sec | 5 min |
| c. Layout curves (per point) | | +/-.0242ft per 100ft | 1 min |
| d. Planetabling (per point) | | +/-.0242ft per 100ft | 1 min |
| 4. Process field data | (Topo) position closure of at least 1:20,000 | | *3-5 min |
| | (Const) position closure of at least 1:5,000 | | *3-5 min |

*Dependent upon amount of stations in traverse scheme.

*(0-2) Issue: Does the AISI provide adequate data transfer capability? This issue will evaluate the capability of the AISI to directly record measured data and transfer that data from its microcomputer to the data recorder and use that data to perform survey layouts. Specifically, this issue will evaluate the capability to "dump" or transfer electronic data via the data recorder and a RS232/V24 interface to an external microprocessor.

Criteria: The AISI, when employed by representative users IAW the OMS/MP will be able to record data in the data collector and transfer that data to the external microprocessor with 90% fidelity, 95% of the time. Representative users will be able to transfer data from the external microprocessor to the data recorder and with that data, use the AISI to layout precomputed distances and deflections with 90% fidelity, 95% of the time.

**Refer to Appendices J3, J4, J5, J6, & J12.**

*(0-3) Issue: Does the AISI demonstrate adequate RAM for operational mission requirements? Data will be collected to determine the AISI's demonstrated RAM characteristics, and to identify potential availability and maintainability problems. Operational RAM characteristics of the AISI will be evaluated as the system is exposed to a variety of environmental conditions while conducting operational missions IAW the OMS/MP. Reliability, maintainability, and logistic support data will be collected and analyzed, and the impact on system readiness objectives and/or operational availability (Ao) assessed.

Criteria: MCBOMF for the AISI must equal or exceed TBD hours. The maintenance ratio for the AISI will not exceed TBD maintenance manhours/hours of operation. Ao for the AISI will be TBD or greater. (Note: RAM parameters will be furnished by USAES from the approved RAM rationale.)

**Not calculated.**

*(0-4) Issue: Are there any safety or health hazards associated with the AISI? This issue will identify and assess safety and health hazards during all phases of testing to include time in storage, transport, maintenance, and operation. All safety and health hazard discrepancies will be recorded and categorized IAW MIL-STD 882B.

**Refer to Issue T-8.**

Criteria: The AISI will not contain any uncontrollable safety or health hazards. The AISI design will comply with applicable safety requirements IAW AR 385-10, 385-16, 40-5, 40-10, MIL-STD 454 and TB MFD 524.

*(0-5) Issue: Is the AISI designed for efficient and effective logistics support? This issue is designed to assess the commercial end items for their logistic support requirements. Areas of consideration are requirements for and availability of common and special tools, TMDE, repair parts, packaging, handling, storage, facilities, supply/provisioning, and standardization. Also considered are commercial operational and maintenance manuals. The frequency and type of logistic-related test incidents will form the basis for subjectively assessing the adequacy of the commercial logistic base.

Criteria: Repair parts and warranties from the manufacturer will be specified and must support the system at all levels of maintenance when fielded. The supply and maintenance organization will be completely described and the responsibility and work flow for each level of supply and maintenance will be clearly defined in the MAC. Integrated logistic support responsibilities, including maintenance and supply will be allocated to the proper level consistent with exiting supply and maintenance

procedures as determined by TOE. Requirements for supply and maintenance facilities will be consistent with current Army facilities, capabilities and allocations.

**Refer to paragraph 13.3.6.**

(0-6) Issue: is the technical documentation for AISI accurate, comprehensive and effective? During testing, test players will be observed while performing operator, maintainer, and supervisor tasks using commercial manuals. Accuracy, comprehensiveness, and effectiveness will be assessed. Comments will be provided in the following areas:

a. Portions of text that are not clear, comprehensive, concise, or accurate.

b. Portions of text that operators, maintainers, and supervisors cannot adequately use, or that are unnecessary, or inappropriate.

Criteria: The AISI technical documentation and other software must correctly describe each of the critical task requirements. Ninety-five percent of trained representative military users, using the technical documentation, will be able to perform 100% of the critical tasks. The Reading Grade Level (RGL) of all technical documentation and training manuals will be within +/- one RGL for the particular MOS.

**Refer to paragraph 2.2.3.2.**

(0-7) Issue: Does the training program adequately prepare the representative soldier to use and maintain the AISI in an operational environment? The intent of the evaluation is to assess the training as outlined in the individual and collective training plan (ICTP), and as representative soldier to established performance standards. Pretest effectiveness by a comparison to post-test skills. Demographic data on test players will be gathered and test players' profiles compared to

representative population profiles obtained from the USA Soldier Support Center. Sources of tasks, conditions and standards identified in the ICTP will be used as the basis for the training evaluations. The entire training package will be assessed and trainer and tester input will be solicited to determine adequacy of training devices, manuals, aids, and other material. Training aids or devices will be evaluated for their effectiveness and ability to influence training transfer. Individual performance will be assessed during normal conduct of the test. Tasks that players have particular difficulty with will be reported and the training program for those tasks, including the performance standards, will be reassessed. Tasks necessary for operation and maintenance that were omitted from the training plan will be reported. A subjective determination of the efficient and effectiveness of the training program will be made using QQPRI obtained during the test.

Criterion: Upon completion of training, 95% of the representative soldiers will be able to perform all of the critical tasks identified in the TTSP to prescribed standards.

**Trained military personnel were not used in the evaluation.**

(0-8) Issue: Can the AISI be transported by all required modes? This issue addresses the transportability characteristics of the AISI. Due to the small size and weight, it is not anticipated that the AISI will have transportability limitations. However, the ability of the AISI to withstand the rigors of transport by vehicle and backpack must be evaluated.

Criteria: AISI will be safely transportable within the using units existing TOE vehicles. The assigned crew will be able to properly package the AISI for transport. The ruggedized carrying case will protect the AISI from damage during

normal transport. The AISI will be man portable in its carrying case and able to be backpacked by the assigned crew.

**The AISI is safely transportable and can be properly packaged for transport. The carrying case is rugged and has survived tests as described in Volume II, Topic 4, pink pages.**

(0-9) Issue: Is the AISI adequately designed with regard to sound human factors engineering (HFE) principles? The issue addressees the AISI design with regard to human factors engineering principles when the system is employed in an operational environment by representative users. Testers will report HFE problems as they occur.

Criteria: The AISI shall meet the human factors engineering requirements of AR 602-1 and MIL-H-46855. Personnel must be able to set-up, operate, and store the AISI in its case while wearing cold weather clothing.

**Refer 2.2.8.2.**

## FIELD OPERATIONAL AND ENVIRONMENTAL EVALUATION

## (AISI)

## CONCLUSIONS

1. The AISI can be operated efficiently and effectively by two qualified military surveyors.

2. The AISI system will increase survey speed and accuracy when operated in accordance with proper procedures.

3. The DRU will store measured survey data that later can be loaded into a survey program/computer for quick turnaround solution. Solutions may consist of:
   (a) Survey data (computer output)
   (b) Maps/charts (plotter output)
   (c) Drawings/graphical representations (plotter output)

4. System documentation was difficult to use and interpret. Although varying in degree of difficulty, none of the supporting documentation was acceptable.

5. Some examples of AISI design weaknesses are: instrument panel keys too small, tendency to water-leak around optics, EDM easily misaligned.

6. A few malfunction codes displayed on the AISI panel cannot be corrected by the surveyor in the field. This determination can not be made until the available literature is searched; a time consuming operation.

## FIELD OPERATIONAL AND ENVIRONMENTAL EVALUATION

## (AISI)

## RECOMMENDATIONS

1. All ancillary software shall be user friendly.

2. It is essential that any supporting documentation be written & styled for easy access to and interpretation of information and operating instructions.

**FIELD OPERATIONAL AND ENVIRONMENTAL EVALUAT'ON**

**(AISI)**

## GENERAL APPENDIX


| Appendix | Volume I | Page |
|---|---|---|
| A | Human Factors | 105 |
| B | Registered Land Surveyor | 109 |
| C | Soldier's Letter-SSG Carl D. Cummings | 111 |
| D | Soldier's Letter-SSG Thomas K. Wallenius | 114 |
| E | Computer Software Description and Evaluation | 119 |
| F | Wild Leitz Fax Message | 124 |
| G | Industrial & Governmental AISI User Comments | 125 |
| H | Bibliography | 133 |
| I | Acronyms and Abbreviations | 134 |
| J | Evaluation Field Data Appendix J | 138 |

# APPENDIX A

## AUTOMATED INTEGRATED SURVEYING INSTRUMENT

## (AISI)

## HUMAN FACTORS

The question to be answered is: Does the AISI conform to human factors insofar as its design and operation are concerned? The areas that must be addressed deal with the ability of the user to perform the tasks that are necessary to accomplish the various surveying functions that are required. Before dealing with the specifics of the systems that were evaluated it seems appropriate to address some overall factors.

### GENERAL

The setup of an instrument in the field is strictly dependent upon the person operating the instrument at that time. Some like to set the instrument high while others vary the height from setup to setup. This fact coupled with the differences in the distance the operator might stand when looking at keyboards and displays, makes the human factors difficult to determine the correct or incorrect placement of the keyboards and displays in relation to height and viewing angle for reading. It should be noted that neither the military personnel observing the evaluation nor the personnel conducting the evaluation commented on problems in viewing the keyboard and display windows. Therefore, these items are not addressed in the specific system writeups. It would be a most difficult task to operate an instrument while wearing cold weather gear. It would be difficult also to operate various control knobs that are necessary to focus the telescope and to position the instrument precisely. These factors have not been addressed in the specific system writeups. The design of the instruments is unique to the function they perform,

and is therefore quite similar from manufacturer to manufacturer. Inasmuch as these items require minimal maintenance, no consideration of the AISI systems human factors design for the ease of maintenance was evaluated.

## WILD SYSTEM

The Wild Survey system has in its human factors design, push buttons on both the instrument and data collector keyboards. The buttons are cylindrical and are approximately one-eighth inch in diameter. They protrude approximately one-eighth inch above the keyboard surface. Buttons are spaced approximately 1/2 inch at their closest points. The shape and spacing make it difficult to operate these items while wearing gloves except to make use of some device such as the eraser on a pencil to assist in pushing only the intended button.

The Wild instrument has an option for mounting opposing keyboards so that controls/displays are in front of the operator irrespective of the instrument's position. The keyboard keys are multi-function with color coding to define the functions. The function selection keys however, are single purpose with color coding for function selection. The data collector design requires that two adjacent buttons be pressed at the same time to initiate the off process. This prevents the accidental turnoff of the collector by pressing one button.

The Wild system has its vertical and horizontal motion control screws mounted on the outside of the right standard (in face I mode). the coarse and fine adjustment controls for each vertical and horizontal motion are colocated on the same axis. The coarse control is a flip type control that is pushed to either the locked or unlocked position. The fine control is a knob that is only effective when the coarse control is locked and is turned using the fingers. The configuration allows the operator to unlock the coarse control, move the instrument to the desired position, lock the coarse control and begin fine adjustment without moving

his/her hand. It should be noted that the shape of the controls is the same for both vertical and horizontal motion. This makes it difficult for the operator to know which control is being grasped except for the relative location of the controls with the vertical motion control being located slightly forward and about two inches above the horizontal motion control.

The telescope on the Wild instrument has focus adjustment for reticle and for the telescope, itself. the telescope adjustment control has an indication of the direction to be turned for infinite focus position. This makes it unnecessary for the operator to remember if its clockwise or counterclockwise.

The Wild instrument has a carrying handle mounted on top which facilitates the movement of the instrument from its carrying case to its position on the tripod. Because of the requirement to plunge the instrument while taking measurements, and the low clearance of the handle, it is necessary to hinge the handle allowing it to be opened. This makes possible a situation whereby the instrument could be picked up without the handle being fully secured.

GEODIMETER

The Geodimeter system in its human factors design, uses push buttons to operate both its instrument and data collector. The push buttons are membrane covered with their functions inscribed on the membrane. The push buttons are located approximately one-half inch center-to-center in both horizontal and vertical direction. This makes it difficult to press the buttons while wearing gloves. The operation is simplified if a pencil eraser is used to perform the function. The display format is a single screen with three lines of data are available at any one time.

The Geodimeter system has two control knobs mounted on the outside of the right standard (in face I position) for locking and unlocking the horizontal and vertical motions. The two coarse control knobs are identical in shape and size with

the two fine control knobs being smaller, but again identical in shape and size. The positioning requires that the operator release the coarse motion control, move the instrument, lock the coarse control and then move his/her hand to the fine adjustment control to complete the sighting.

The telescope on the Geodimeter instrument has focus controls for the reticle and for the telescope, itself. The telescope focus ring is large and easy to grasp. It does not have an indicator as to infinity focus which is a problem only if one does not use the instrument daily and therefore remembers the direction of rotation to achieve near or far focus. The telescope eyepiece presents a different appearance in that the eyepiece is offset within the focus ring.

The Geodimeter instrument has an integral carrying handle to move the instrument from carrying case to tripod. The carrying case opens like a suitcase into two halves and contains a cutout area into which the instrument will fit. This means that the instrument is inserted straight into the cutout and is removed in the reverse way. The handle fits right against the edge of the cutout, and the hand cannot grasp the handle and pull the instrument out, but rather both hands must be used to put the instrument in or take it out of the case.

There is only one keyboard on the Geodimeter instrument. Because of the method used to initialize the instrument, there is an ENTER function button mounted on the instrument opposite the keyboard. This means that in the face II position, the operator has to walk around the instrument to complete the readings once the sighting has been accomplished.

CUBIC

No human factors evaluation has been provided because the system was removed from evaluation when the manufacturer declared their item unable to pass the proposed environmental testing.

## APPENDIX B

## CONTRACTOR QUALIFICATIONS

Everett D. Grissom, P.L.S.

500 Lafayette Boulevard, #220
Fredericksburg, Virginia 22401
(703) 371-0268

December 31, 1987

### EDUCATION:

Graduate of Williams High School, Williams, Indiana, May 1958

Completed Highway Technician Course, Perdue University, Lafayette, Indiana
June and July, 1958

### PROFESSIONAL LICENSE AND MEMBERSHIPS:

December 1974 - Received Virginia Land Surveyor's Registration, No. 1205, to operate in Virginia as a Professional Land Surveyor.

Member - Virginia Surveyor's Association

Member - American Congress of Surveying & Mapping

### EMPLOYMENT HISTORY:

May 1975 - Present:

Maintained operation of private business as Everett D. Grissom, Surveyor, P.C.

December 1973 - April 1975:

T. L. Bays Surveying Company, Ladysmith, Virginia
Computator and office manager for boundary surveying

April 1969 - November 1973:

Dewberry, Nealon & Davis, Fairfax, Virginia
Party chief, boundary survey, construction stakeout and topo surveys

December 1968 - March 1969:

Michael Baker, Jr. Survey Co., Pennsylvania
Instrument man, 2nd order traversing in Pennsylvania

June 1968 - November 1968:

Ralph Rogers Construction Co., Bloomington, Indiana

Party chief and instrument man for miscellaneous construction surveys

May 1959 - June 1968: U.S. ARMY

May & June 1959: Basic training, Fort Leonardwood, Missouri

July & August 1959: Topographic Surveying Course, Fort Belvoir, Virginia

September 1959 - August 1961: 29th Engineering Battalion, Corps of Engineers, Tokyo, Japan. Levelman, 3rd order leveling. Instrument man, topo with alidade. Instrument man, 2nd and 3rd order traversing in Pacific Islands. Three months on the job training as Wild T-4 operator. Promotion from Pvt. E-2 to Sp-5.

September 1961 - May 1962: U.S. Army Missle Base, White Sands, New Mexico. Classified Surveys.

June 1962 - February 1963: 30th Engineering Battalion, Fort Belvoir, VA. Instrument man and party chief, 3rd order leveling and 3rd order traversing.

March 1963 - March 1964: 40th Engineering Co., Korea. Party chief for 3rd order traversing N.C.O.I.C. Benchmark Recovery Program. Promotion from Sp-5 to Sgt. E-6.

April 1964 - April 1966: 29th Engineering Battalion, Tokyo, Japan. 18 months as party chief, Wild T-4 astronomical observations, Southwest Pacific Project, and 4 months N.C.O.I.C., Southwest Pacific Project computations, 1st order of Sodono Method of Azimuth and Astro Observation.

May 1966 - May 1967: U.S. Army Engineering School, Fort Belvoir, Virginia. Second phase leader, topo computing course.

June 1967 - May 1968: 569th Engineering Co., Vietnam Platoon, Sgt, 2nd and 3rd order traversing.

Returned to civilian with an Honorable Discharge from the Army.

August 1958 - April 1959:

Indiana State Highway Department - Highway Technician

APPENDIX C

3 June 1987

SUBJECT: Observations of AISI Test Program

TO: Mr. Mark H. Thomas
Belvoir Research, Development and
Engineering Center
Fort Belvoir, Virginia 22060

1. First I would like to state that I feel the military has a definite need for a system of this type. The increase in efficiency and reduction in manpower requirements for these types of instruments is immense. A typical survey mission requiring 3 to 4 people can be accomplished by 2 people in less time. Also, this type of system utilized with a Data Collection System and CAD type software also reduces the workload of draftsmen, i.e., a 300-400 shot topo which normally takes a draftsman 2 days to draw and contour, can be done in minutes by a computer. Because of the increase in efficiency and reduction of manpower requirements I personally don't see how the Army could afford not to acquire systems of this nature.

2. Second, during the test phase I talked to several individuals who voiced concern over soldiers ability to operate equipment this sophisticated; they need not worry. Sometime in 1981-1982 the 18th Engineer Brigade was given Zeiss Elta 3s by E.U.D. to use in support of the Grafenwohr Range upgrade projects. These Elta 3s are Total Station instruments, the surveyors had little or no trouble learning to use them, and their use was in important factor in completing these ranges from 82-84. After the completion of the ranges these instruments were turned over to the Battalions of he 18th Brigade and are still in use today. The only problem the Elta 3s caused the soldiers was lack of quantity. We had 4 and needed 10.

3. Next I would like to state my observations about the instruments in the test program: Wild T2000, Geodimeter 440, and Cubic DT-1. First let me state that all three instruments would perform any task a construction surveyor would be called upon to perform. All three would be a tremendous improvement over the equipment presently in the field. But if I could choose the instrument it would be the T2000, hands down! Now I will point out my likes and dislikes about each instrument.

a. Wild T2000: The T2000 is an extremely well built instrument. The finish and fit of the components is superb. There are no exposed wires between the Ranger and the instrument to break or get lost, everything is internal or "hard" surface contacts. All control knobs turn smoothly and are also "handy", easy to reach. But the two features I liked best were the dual keyboard and displays and its ability once connected to the GRE 3, to do everything from the instrument, you don't have to touch or look at the Data Collector again. I also feel that the T2000 was the easiest instrument to use and it would be my choice.

b. Cubic DT-1: Although the Cubic will do anything required and once it is set up it's easy to operate I don't like it. Number one, it "hit" me, when the vertical clamp is released the eyepiece and Ranger "flop" downward, because it's not balanced. Second, there are too many pieces to assemble, it takes to long to set up. Also, the wire from the Ranger to the instrument is small and flimsey, we had to replace it during the test. Next, the finish and fit of this instrument was poor, gaskets missing, objective lens badly scratched, and tribrach unserviceable. Overall, although it would do the job; as far as I'm concerned and I'm sure all left handed people would agree, because of the focus control knobs' location to the right of the telescope it is very difficult to focus.

c. Geodimeter 440: This instrument is also well built, fit and finish superb. I think it is as good as the Wild T2000 with the exception of dual keyboards. It's easy and fast to set up and has the advantage of having an internal Ranger. Of the instruments tested this would be my second choice, after the Wild T2000.

4. Next, I would like to discuss Data Collectors briefly. All three worked well and were easy to operate. The Wild and the Geodimeter had an advantage that they could be pre-loaded for layout work. The Geodat 126 has as it's main component a HP41CX which is in itself an extremely helpful tool. Overall I think either the Wild or Geodimeter are fine data collectors, but I strongly feel that the instrument is the primary part of the system and whichever is chosen, all other components should come from the same supplier, if possible.

5. Software is without doubt going to cause the most problems in fielding a system of this type. None of the instruments were difficult to use, or took long to learn to operate, but learning to use the software was at times very frustrating. We had two software packages to test and evaluate, RETRIEVER and CIVILSOFT.

a. RETRIEVER: RETRIEVER's package was a powerful system and included VERSCAD 50 and Design Plus. Although it had many uses to a civil engineer or surveyor it was frustrating to operate, i.e., command codes sometimes had to be capitals, sometimes not. You never knew until you tried one. Aside from that I used it to compute horizontal curves, calculate end areas, determine earthwork requirements and other civil engineering type problems; the system worked well and was simple to operate. VCAD 50 also was easy to use and operate. Overall it is a good package and adequate for our needs.

b. CIVILSOFT: This software package is more user friendly, a very important factor in my mind. Otherwise it has basically the same capabilities as the other system, and is the one I prefer because of its ease of operation.

6. Recommendations:

a. Use a single source to purchase all components of system, including software. A matched system is always easier to operate than odds and ends.

b. As soon as possible acquire and field a system, we really need them.

c. Prior to fielding the system, rewrite any and all Owner's Manuals. Make them "Soldier" proof.

Carl D Cummings

CARL D. CUMMINGS
SSG, USA
Instructor, Survey Division
Department of Geodesy and Survey

## APPENDIX D

FINAL REPORT

I would like to present a set of observations from my experience during the testing of the Automatic Integrated Survey Instrument (AISI). I had the opportunity to observe and use the three competing units in the field and to be a part of the office operations involving the various computers, programs, printers, and plotters.

As a geodetic surveyor I saw an immediate use for any AISI. I could see the streamlining of the field work with possibly only one person at a station and all records going directly into the data collectors. The data collectors stored only a limited set of field data, but each was programmable so that with slight additional work all could follow a high order observation such as a multiple horizontal angle observation.

There was an inability to download the information in the data collectors to the main computer that was not resolved before I was pulled off the project. I did see the download procedure on a smaller computer and foresee no problem with this.

So far the geodetic surveyor would find a real use for the field instrument , data collector, and the downloaded data in an IBM-PC type computer.

The trouble that I did see was with the software, there was no software on the project that could be used to perform a geodetic survey. There were some very sophisticated programs for surveying and drafting as used in civil engineering and construction surveying and could be applied in low order projects such as airfield and boundary surveys.

## DATA COLLECTORS

The Wild GRE3 was a very advanced data collector. It was extremely flexible, and easy to use. The documentation was hard to read. The GRE3 worked with little attention because most of its functions were activated from the T-2000 keyboard. It was also very easy to use as a manual data entry device. The GRE3 is programmable in BASIC, but the program must be written as a text file on a computer and downloaded into the GRE3. After a short familiarization I felt very comfortable with this data collector. The GRE3 is provided with a bubble memory that maintains data without any electrical power. This makes the data safe.

The Cubic data collector was a commercial unit with a Cubic program housed in a ROM chip. The initial data collector did not work, but the replacement worked without problems. The program and the easy to follow documentation provided by Cubic made this very easy to use. It was BASIC programmable from the keyboard. The one shortcoming this data collector had was that it could only collect data and not provide data for the survey instrument. This data collector works with rechargeable batteries and is provided with an internal battery that is said to maintain the data for a month.

The Geodimeter data collector was a HP-41CX calculator in a special case with additional programs. Other than a reliance on the calculator batteries to maintain data (and the batteries did seem to get used up fast) this was a useful data collector. The additional programs provided many features that could compute information in the field without a need to return to the office. As an example if one was setup at a point and initialized at a corner of a proposed building the programs could compute where the next corner was to be and send up to the survey instrument what the horizontal angle, vertical angle, and slope distance was to the location. This would be a useful feature in construction, and can also be done on the GRE3.

## NOTES ON SURVEY INSTRUMENTS

The Wild T-2000 was an outstanding instrument in terms of ease of use and operation. The manuals provided were very long, boring, and technical and it took a lot of reading and effort to learn how easy the instrument was to operate. One problem was that the instrument and the distance measuring unit had to be moved in separate containers, so that there was a bit of assembly work at each setup. It was the only instrument with a display on two sides, a real need with direct/reverse observations.

The Cubic was entirely in too many pieces for rapid use and movement. The instrument itself was roughly made and had several obvious oversights such as a lack of seals. The instrument was bulky, and to me, dangerous. The distance measuring unit hit several of us on the head when the vertical clamp was released. The display was hard to read except when looking straight at it. The time it took for the instrument to set itself up from one observation to the next seemed excessive. In favor of the instrument was the internal memory for 200 observations, and I cannot fault the unit in terms of use once it was set up (and the vertical clamp was secure).

The Geodimeter was compact, easy to set up and not too difficult to use. We did have trouble with getting the instrument and the data collector to operate because of the seemingly overcomplex documentation. The one excellent idea this instrument had was a double electronic bubble. With it the instrument could be leveled with no movement. I believe with a little experience this instrument would be the quickest to use. Geodimeter also provided software which I did not get an opportunity to use.

SOFTWARE PROGRAMS

In reference to the programs:

The main program we used was Retriever, written by Cadserve. This was a very powerful program that performs all the data recording, data transfer, computations, and drawing files. It also produces files that more complex programs can access. With the aid of a drafting program called Versacad a complete project from field to final reports, and drawings is performed. The program can be used with many data collectors, and provides a fairly complete drawing with little help. The biggest problem with this program is that it is very complex, and that the drawing requires many codes that make field work confusing. This program takes a lot of trial and error to understand. The documentation is good, if one performs the field work exactly as the program requires. One must also be fairly familiar with the computer operating system in order to fully utilize the program features. Hand written field notes are a pain to input and all data is a pain to edit.

If one wants area topo and one is willing to devote a lot of time to training Retriever program will do.

Design Plus is a program that does many civil engineering/construction calculations. It also has a set of survey calculations. This program can access files generated by Retriever and can also be used with manual entry. The survey traverses I tried to run using this program did not work. The documentation may have been the problem. This program was very hard to operate at many points.

Collect, COGO-PC,and Contour are programs by Civilsoft. This was the set provided by Cubic. To me this was a very good set of programs. Collect is the data communications program which is simple and easy to use. COGO-PC and Contour were well written and not too difficult to use. I did not have enough time or data to fully test the programs, but in terms of user friendliness this was much better than Retriever, and the programs worked as the documentation said they would. There was still a lot of manual reading in order to use the programs.

I would like to mention a coordinate conversion program written in West Point. To me this was an excellent example of what the Army needs. The program was easy to understand and simple to use and it did the job. I believe all survey programs should be like this in terms of user friendliness.

## RECOMMENDATIONS

While the Cubic setup was, in many ways, the most primitive, the fact that it was a complete set from field equipment to plotter gave it an overall edge. Also the Cubic documentation was the easiest to follow. While I would not recommend the Cubic system I would recommend that any system be purchased as a complete system from one source.

I also recommend that geodetic survey adapt to the new technology and not burden the technology with possibly obsolete procedures. I am referring to observations of direct/reverse positions using optical plate procedures when the electronic plates are claimed to be more accurate ( Geodimeter specifically states that direct/reverse observations are not needed ). An update on procedures is needed from NOAA or somebody. Also in certain computations could it be possible to ease the many correction factors, and mathematical/arbitrary error compensations presently being utilized in return for the immediate use of available programs?

In reference to geodetic survey software. I would recommend that the army geodetic survey field try to avoid developing a program set. I recommend that the specific needs of a geodetic survey program set be defined as quickly as possible and that commercial software developers be contracted, preferably those who have written good survey programs in the past.

Trying to get the generic pieces to work together was personally very frustrating, and when problems arose we had to go to one place for the computer, another for cables, another for program assistance and yet another for field assistance. This would not work for troop units. My primary recommendation is to purchase complete sets from one source with simple to follow documentation to make the whole system function.

Thomas K. Wallenius

Thomas K. Wallenius
SSG, USA

## APPENDIX E

## AISI SYSTEM SOFTWARE

The system software should be a fully integrated, three dimensional, ground modeling, design, and drafting system. The system should include such applications as field note reduction, automated data collection, traverse balancing, surface modeling, contour mapping, coordinate geometry, roadway design, drainage design, earthwork volumes by average-end-area or true prismoidal calculations, and three dimensional projections. The software shall be compatible with MS-DOS operating system and shall run on the standard Army Command and Control System harware. The software may contain separate packages to perform functions such as drafting and/or design calculations however maximum integration into one package is highly desirable. Software application will be in the two areas of Topographic (control) survey and Construction survey. In both areas the software will be required to transfer data between recorder and processor and to the peripherals such as printer and plotter. Representative tasks to be performed in the topographical area include: storage of raw field data; compute, adjust, plot and annotate three dimensional coordinates using coordinate geometry (includes travers, intersection, and resection); compute a level line; compute astronomic azimuth (stellar); coordinate conversion, (UTM, to Geographic, WGS, State Plane); zone to zone conversion (UTM); and compute convergence of coordinate lines. In the construction survey task area the following representative tasks are critical: storage of raw field data; compute, adjust, plot, and annotate three dimensional coordinates using coordinate geometry (includes traverse, intersection and resection); compute level line; compute and format for field location, road, airfield, buildings, and utilities (centerline, grade, earthwork); compute and plot profiles, cross sections, vertical curves, and horizontal curves; compute and plot preliminary/final road, airfield and architectural

construction plans. In both areas the software must not only process data input through the keyboard and from the data collectors but be able to output certain processed data to the data collectors and the other system packages for their use. Software must be interactive, menu driven and user friendly to the maximum extent possible.

## AISI SOFTWARE EVALUATION

Software evaluation will be conducted using contractor supplied hardware and with data that has been contractor generated Government approved. The evaluation will be conducted in a manner that will demonstrate all aspects of the system software. Complete records of all software evaluation will maintained. The hardcopy output products of the processing actions will be considered as record of the evaluation procedure. The selected software will be loaded on the selected hardware using the procedures provided by the software manufacturer. Problems and/or difficulties in correctly loading the software will be recorded. Once the software has been loaded and is functioning correctly data, by type, will be entered for processing. Sufficient data will be entered to demonstrate the functions required. Hardcopy output will include raw data, edited data, all files developed, and the processed data necessary to demonstrate compliance with the various survey function requirements.

APPENDIX E

DEFENSE MAPPING AGENCY

DEFENSE MAPPING SCHOOL

FORT BELVOIR, VIRGINIA 22060-5828

IN REPLY REFER TO

CS

18 DEC 1987

SUBJECT: Automated Integrated Surveying Instrument Software Evaluation Report

TO: Commander
U.S. Army Belvoir Research, Development and Engineering Center
ATTN: STRBE-JCT
Fort Belvoir, VA 22060-5606

1. Reference ongoing working arrangement between Defense Mapping School (DMS), CW3 Thomas Besch, Trainer and Belvoir Research, Development and Engineering Center (BRDEC), Material Developer.

2. Background: In response to a request from BRDEC, August 1987, selected instructors from the Advanced Geodetic Survey Course were tasked by CW3 Besch to assist in the evaluation of commercially available surveying software packages. The instructors were to evaluate the compatibility of the software packages with the requirements of the military topographic and construction surveyor and make recommendations based upon the evaluations.

3. Facts and Discussion: Five commercially available survey software packages were made available for evaluation. They are as follows:

a. Wildsoft by Wild Heerburg Instruments, Inc.
b. Retriever by CadServ
c. Advanced Designer Series by Civilsoft
d. Design Plus by E.S. Computer Sales, Inc.
e. Geodimeter Surveying Software by Geodimeter

4. A complete and comprehensive evaluation was not accomplished for all software packages that were available. A number of reasons prevented this. Chief among these was the fact that none of the packages will by itself meet all of the specified requirements for the topographic surveyor and the construction surveyor. Another major reason was that the packages do not permit hand entry of the field data as of this evaluation. However, it appears to be possible to put data into the microcomputer by using an edit function.

5. With the above information and the knowledge that the majority of the packages are in their infancy, the following recommendations are made:

a. That a baseline starting set of software packages be established to include the following:

(1) Advanced Designer Series by Civilsoft
(2) Retriever by CadServ Incorporated
(3) Wildsoft by Wild Heerburg Instruments Inc. (if a version of Wildsoft is produced that requires only one monitor; current version requires two (2) monitors, a graphics monitor and a text monitor.)

b. That a computer assisted drafting package be included as part of the set. Reason: All packages in recommendation #1 generate a plot file and coordinate file; however, they in themselves will not produce the actual contour map or drawing. They require a drafting program; both Autocad and/or Versacad can fulfill this requirement.

c. That a word processing program also be incorporated into the set for the writing of progress reports, incidental administrative type reports, and after action reports.

6. As previously stated, none of the surveying packages fulfill all requirements at this time. There are additional programs available or in the developmental stages to satisfy the geodetic portions of the requirements. In connection with the Department of Computer Science at West Point, the Defense Mapping School's Survey Division is developing software to be placed in the public domain that will satisfy a vast majority of the requirements not met by the commercially available software.

David F. Maune
DAVID F. MAUNE
Colonel, USA
Director

Mark; Here is a list of the software names and addresses that we have looked at or used. I am also attaching the info on another program that we did not make use of or even inquire about.

RETRIEVER
CADserv Inc.
37800 Hills Tech Dr.
Farmington Hills, MI 48018

CIVILSOFT
290 S. Anaheim Blvd., Suite 100
Anaheim,CA 92805

WILDsoft
Wild Heerbrugg Instruments, Inc.
Geodesy and Industrial Systems Center
40 Technology Park/Atlanta
Norcross, GA 30092

GEODIMETER
385 Bel Marin Keys Blvd.
Novato, CA 94947

VERSACAD
T & W Systems, Inc.
7372 Prince Drive, Suite 106
Huntington Beach, CA 92647

DESIGN PLUS
Computer Sales Inc.
191 Woodport Road
Sparta, NJ 07871

# FAX MESSAGE

APPENDIX F

Konzernbereich
Instrumente + Systeme
Geschäftseinheit Geodäsie
Wild Heerbrugg AG
CH-9435 Heerbrugg

WILD LEITZ

Telefon (071) 70 31 31
Telefax II/III (071) 70 31 52
Telex 881 222 wi ch
Telegramme Wico Heerbrugg

To: E. Leitz Inc. 001 201 767 4196

Attn.: John Riddell

Subj.: High Altitude EMP Info for Ft. Belvoir

From: Armin Spiegel

Ref.:

Date: 16.09.1987

Distr.: 3379, 3376

Pages:

General Information:

In the case of a High Altitude Electromagnetic Pulse the damage to electronic equipment is primarily not caused by the direct influences of the fields, but by secondary effects, like induced current- and voltage impulses. Therefore one must prevent long cables or distributed wiring without shielding.

Basically all metallic, conductive objects can pick up electromagnetic energy. How much, depends on the

1) EMP characteristics
2) wave propagation characteristics and the
3) electric and geometric characteristics of the object.

Pt. 1 and 2 would have to be supplied by the one concerned about EMP, because there are different scenarios. More information can be found in the following literature:

**Electromagnetic pulse interaction close to nuclear bursts and associated EMP-environment specifications**
C.E. Baum, AFWL-Sensor and Simulation notes SSN-76, Kirtland AFB/New Mexico, Air Forces Weapons Laboratory, 1971

Possible Actions: In general an extensive analysis is required to compute the induced currents and voltages.

We have not done and presently do not intend to do any analysis for this case except it could be billed or recovered by a larger order. If any further investigation would be necessary, we would have to hire a consultant. To my knowledge testing facilities for HA-EMP are available in Switzerland. The cost for such a test are not available at short notice and I don't know if we even would get access to it. Please let me know, if I should pursue it.

Sorry, I can't give you a better answer, but EMP so far has not been of primary concern to us.

Regards,

Armin Spiegel

APPENDIX G


# DECKER COAL COMPANY

P.O. BOX 12

DECKER, MONTANA 59025-0012

(406) 757-2561


June 12, 1987

Mark H. Thomas, Project Engineer
Topographic Systems Team
U. S. Army Belvoir Research
Development and Engineering Center
Fort Belvoir, Virginia 22060-5606

Dear Mr. Thomas:

Decker Coal Company purchased a Wild T-2000 Total Station Instrument in January 1986. Because of our relatively short period of use you may want to weigh our evaluations accordingly. Decker Coal is an open pit coal mine situated in the south east corner of Montana. The climate here encompasses almost all situations.

In the period of time we have used the T-2000, temperatures have varied from 100F in the summer to -20F in the winter. Use at the mine exposes the instrument to all the elements plus a considerable amount of dust. There have been no problems with the function of the T-2000 in any situation we have exposed it to thus far. Accuracy of the gun has not been impaired due to extreme weather conditions. The functions are slower when the temperature reaches 20F to 0F. Distance takes longer to display as well as angular display being slower when temperature is at that range, however, accuracy is not impaired.

Along with the T-2000 Theodolite, we purchased a 32K GRE-3 Data Terminal. This machine has also been exposed to dust and elements and like the T-2000 has required no service.

Our mapping needs require at least monthly surveys of our Pits for lease payments and state records. The T-2000 plus the Data Terminal have been very useful in aiding in the accuracy and efficiency of these maps. The data collector eliminates the need for a person to take notes. Once a numeric code system has been set up all notes can be entered into the terminal from the keyboard of the T-2000.

Mark H. Thomas, Project Engineer
Topographic Systems Team
U. S. Army Belvoir Research
Development and Engineering Center
June 12, 1987
Page Two

Decker Coal Company utilizes a Perkin-Elmer computer system that is compatible with the Wild Total Station System. Programming was done in-house without the use of additional software. Our system is set up to allow us to dump the collected data, reduce it to X, Y, and Z coordinates and plot the maps from one program. We have done in excess of 150 individual points from data collector to finished map in less than 15 minutes.

The T-2000 and GRE-3 can store your X, Y, and Z coordinates as well as angular measurements. With a different system one could probably increase efficiency by using the already reduced coordinates to plot directly from the GRE-3 memory.

Overall, the Wild T-2000 electronic Thoedolite and the GRE-3 Data Terminal have been maintenance free and relatively easy to operate.

I hope this information helps you in your evaluations. Should you have any questions or need any additional information please contact me.

Sincerely,

Cliff Sorenson

Cliff Sorenson
Survey Party Chief

/ts

CITY OF DES MOINES

ENGINEERING DEPARTMENT
CITY HALL
EAST FIRST AND LOCUST
DES MOINES, IOWA 50307
(515) 283-4931

ALL-AMERICA CITY 1949,1976,1981

June 9, 1987

Mr. Mark H. Thomas
Engineer
Department of the Army
U.S. Army Belvoir Research
Development and Engineering Center
Fort Belvoir, Virginia 22060-5606

Dear Mr. Thomas:

The City of Des Moines purchased 2 Wild T2000 Total Stations. This was done after considerable study and attending 1 Wild operations course and several surveying equipment shows. The City is very happy with the T2000. Although the City does not endorse or recommend any equipment, I can relate our experience with the T2000s. We have had them for 1 year. They seem to be quite rugged and operate at a lower temperature than our Leitz equipment. The equipment and data collecto have functioned well in the field.

We have not received full benefit of the equipment because Engineering has not decided which direction to go with our software. We have been able to dump the field data into our computers with software which does horizontal survey work. We found it necessary for our Surveyors to work very closely with our computer people to get the equipment to work initially, as the instructions provided by both Wild and the software salespeople proved inadequate. We had to discover some things for ourselves by setting the instrument up next to the computer and experimenting with the data collector.

The reason we selected a T2000 is because we are deeply involved in first-order control surveys as well as construction surveys in the existing downtown area where we have to maintain a horizontal and vertical precision of 0.01 foot and an accuracy of 0.02 foot. We have an extensive Skywalk Program. The instruments have been extremely valuable to us in the conducting of land surveys, control surveys, and design surveys.

I hope this information will be a help to you. If you wish to contact me, my phone number is (515) 283-4589.

Very truly yours,

Michael M Klapp

Michael M. Klapp, P.E., L.S.
Principal Civil Engineer

MMK:bhh

United States Department of the Interior
BUREAU OF RECLAMATION
Missouri Basin Region
Belle Fourche Projects Office
P.O. Box 226
Newell, South Dakota 57760

IN REPLY
REFER TO:

JUN 2- 1987

Topographic Systems Team
U.S. Army Belvoir Research,
Development and Engineering Center
Fort Belvoir, Virginia 22060-5606

Gentlemen:

In response to your query on total station instruments, we are pleased to provide the following comments.

We have been using a Wild TC-2000 total station for approximately six months. The instrument has been used for a wide range of applications including precise trilateration to monitor movement of an earthfill dam, alignments, profiles and cross sections of canals and laterals for gathering design data, and providing horizontal and vertical control during construction.

We have used the instrument during winter and spring conditions and it has functioned well. We have not yet used it in extreme summer heat.

The instrument is user-friendly. The instrument control panel is well laid out, easy to read and understand. The spacing between buttons is adequate for use with gloves during cold weather. The displays show up well in all light conditions. Angle and distance measurements are both fast and accurate. All parameters required when setting up the TC 2000 are easily and rapidly determined and inputed.

Since we have only had the TC 2000 for six months we cannot comment on the long term reliability of the instrument. The complexity of the total stations limits the amount of user maintenance that can be performed. Care in handling and using the instrument and keeping clean are a must.

Our TC 2000 recently had to be returned to Wild's Service Center in New York for repair. The internal power supply circuitry shorted out and had to be replaced. Wild provided a 24-hour turnaround on the repair, but total turnaround time from this office to dealer to Wild Service Center and return totaled four weeks.

We have not used the TC 2000 in combination with any software packages so cannot comment on them.

Based on our limited time of using the TC 2000, our overall impression of the instrument is very positive. The instrument increases the productivity of our survey crew over a theodolite and EDM combination.

Sincerely,

Ronald W. Wilkinson

Ronald W. Wilkinson
Acting Project Manager

Thomas

STATE OF MAINE
# DEPARTMENT OF TRANSPORTATION
TRANSPORTATION BUILDING
STATE HOUSE STATION 16 AUGUSTA, MAINE 04333

mdot

DANA F. CONNORS
*Commissioner*

June 23,1987

Mark H. Thomas
Department of the Army
U.S. Army Belvoir Research, Development and Engineering Center
Fort Belvoir, Virginia 22060-5606

Dear Mr. Thomas:

The Maine Department of Transportation owns one Wild T2000 with a DI 5 distance meter, one HP 3820A, and two Leitz SDM3ER Semi Total Stations. All of these instruments are user friendly, have been very reliable and easily maintained. We do not have data collectors at this time.

The Wild T2000 is dedicated to a large bridge project at this time but will be used in the Geodetic Control Survey Unit following completion of that project. The HP 3820A is used for control surveys of various types. Both Leitz instruments are used for traverse work on all projects where new right of way is to be acquired. These instruments are used in all weather conditions except rain, sleet or blowing snow.

I believe that "National Geodetic Survey" has done intensive testing of total station equipment at their Virginia test site. Perhaps you should contact them for additional data.

We can be of further assistance to you, please let me know.

Very truly yours,

David A. Ober

David A.Ober, Engineer
Location & Environment

DAO/jb

cc: R.A. Coleman, Chief Engineer

**Department of Transportation and Development**

Robert G. Graves
Secretary

P. O. BOX 94245
BATON ROUGE, LA. 70804-9245
(504) 379-1131

Edwin W. Edwards
Governor

June 9, 1987

Mr. Mark H. Thomas
Department of the Army
U. S. Army Reserve, Dev. & Engr. Center
Fort Belvoir, Virginia 22060-5608

SUBJECT: Evaluation of Total Station Instrument

Dear Mr. Thomas:

The Louisiana Department of Transportation and Development uses two total station survey instruments in the Preliminary Engineering Section. Both are Wild TC-2000 with GRE-3's. The Wild instrument fit our requirements to interface with our Intergraph System.

The climate in Louisiana is very humid with some very hot days. We generally do not use this instrument during rain.

We have found this instrument to be user friendly and reliable. Its' range is sufficient for the type of project it's being used for. We have also found that the GRE-3 while being user friendly, it is not as reliable as the TC-2000. It appears that all of our problems are a result of battery contacts which needed to be redesigned.

We are using the total station to field record survey data required to design and build highways. This instrument allows not only the recording of an object's position, but also pertinent information about this object. We have developed our own software to interpret this data. We also use the Wild supplied instrument software which allows for a code block with four informational parts and a measurement block consisting of the horizontal angle, vertical angle, and the slope distance.

We have not found it to be cost efficient to use the total station for cross-sections, but we still have testing to do in this area.

I am retiring after approximately 44 years service. My retirement is effective June 15, 1987.

If you need any further information on this matter, contact Mr. Eric Jeansonne who is our Photogrammetrist

in charge of this development. He is at same address.

Yours very truly,

Clarence J. Tircuit

CLARENCE J. TIRCUIT
LOCATION & SURVEY ENGINEER

EJ:plw

## APPENDIX H

## AUTOMATED INTEGRATED SURVEYING INSTRUMENT

## (AISI)

## BIBLIOGRAPHY


1. Topographic Support System (TSS) Required Operational Capability (ROC)-1978.
2. Combat Support Engineers and Mine Warfare, Mission Area Analysis-May 1983.
3. Operational Land Organizational (O&O) Plan for an AISI-TRADOC approved October 1986.
4. Operational/Environmental/Suitability Test Plan For Automated Integrated Surveying Instrument (AISI)
5. Independent Evaluation Plan for the Market Investigation of the Automated Integrated Surveying Instrument (AISI) -September 1987
6. Test & Evaluation Master Plan (TEMP) for the Automated Integrated Surveying Instrument (AISI)
7. Environmental Testing of Automated Integrated Surveying Instruments (AISIs) - National Technical Systems
8. Environmental Testing of a Transportation Trunk - National Technical Systems
9. Independent Evaluation Plan for the Automated Integrated Surveying Instrument (AISI), U.S. Army Engineer School, Directorate of Combat Developments, Fort Belvoir, Virginia
10. Test & Evaluation of Total Station Instruments Federal Geodetic Control Committee

## APPENDIX I

## FIELD OPERATIONAL AND ENVIRONMENTAL EVALUATION

## (AISI)

## ACRONYMS AND ABREVIATIONS

| Symbol | Description |
|---|---|
| $A_o$ | Operational Availability |
| AISI | Automated Integrated Surveying System |
| BOIP | Basis Of Issue Plan |
| B.S. | Backsight |
| Btu | British thermal unit |
| cm | Centimeter |
| C | degrees Celsius |
| CAD | Computer Aided Design |
| COGO | Coordinate Geometry |
| #1 | Point #1 |
| #2 | Point #2 |
| CUCV | Commercial Utility Cargo Vehicle |
| DMS | Defense Mapping School |
| DRU | Data Recording Unit |
| DS | Direct Support |
| E | Easting |
| EDM | Electronic Distance Measuring |
| EMI | Electromagnetic Interference |
| EUD | European Utility Division |
| F | degrees Fahrenheit |
| FD/SC | Failure Definition/Scoring Criteria |

| Symbol | Description |
|---|---|
| FOT&E | Follow-on Test & Evaluation |
| GS | General Support |
| Geod. | Geodimeter 440 |
| GPS | Global Positioning System |
| g | Gravitational Acceleration 980.6 cm/sec$^2$; 386 in/sec$^2$ |
| HA | Horizontal Angle |
| HA-EMP | High Altitude Electromagnetic Pulse |
| HFE | Human Factors Engineering |
| In. | Inches |
| IAW | In Accordance With Instrument |
| ICTP | Individual & Collective Training Plan |
| IER | Independent Evaluation Report |
| ILC | Integrated Logistic Support |
| km | Kilometer |
| LCD | Liquid Crystal Diode |
| M. | Meter |
| MAC | Maintenance Allocation Chart |
| MCBOMF | Mean Cycle Between Operational Mission Failure |
| MFP | Material Fielding Plan |
| MOS | Military Occupational Specialty |
| mph | Miles Per Hour |

## ACRONYMS AND ABREVIATIONS (Continued)

| Symbol | Description |
|---|---|
| MS-DOS | Micro Soft-Disk Operation System |
| MTBF | Mean-Time-Between-Failure |
| N | Northing |
| NDI | Non-Developmental Item |
| NOAA | National Oceanographic & Atmospheric Agency |
| NTS | National Technical Systems |
| O/E/S Test Plan | Operational/Environmental/Suitability Test Plan (AISI) |
| O&O | Operational & Organizational |
| Offset | Alignment Offset |
| OMS/MP | Operational Mode Summary/Mission Profile |
| PAC | Parts Allocation Chart |
| PADs | Position and Azimuth Determining System |
| PPM | Parts Per Million |
| QQPRT | Qualitative & Quantitative Personnel Requirements Information |
| RAM | Reliability, Availability, Maintainability |
| REC | Record |
| RGL | Reading Grade Level |
| ROC | Required Operational Capability |
| RRR | RAM Rationale Report |
| RPSTL | Repair Parts & Special Tool List |
| SD | Slope Distance |
| Sec | Seconds |

## ACRONYMS AND ABREVIATIONS (Continued)

| Symbol | Description |
|---|---|
| SEDME-MR | Surveying Equipment, Distance Measuring, Electronic Medium Range |
| T & E | Test & Evaluation |
| TECOM | Test & Evaluation Command |
| TMDE | Test Measuring & Diagnostic Equipment |
| TOE | Table of Organizational Equipment |
| Trav. #1 | Traverse #1 |
| Trav. #2 | Traverse #2 |
| TSS | Topographic Support System |
| TTSP | Training Test Support Package |
| USAES | United States Army Engineering School |
| UTM | Universal Transverse Mercator |
| V | Volts |
| Vert | Vertical |
| WGS | World Geodetic System |
| $\sigma$ | Standard Deviation |
| $v$ | Residual |

## FIELD OPERATIONAL AND ENVIRONMENTAL EVALUATION

## (AISI)

## APPENDIX J

## EVALUATION FIELD DATA

### TABLE OF CONTENTS


| Appendix | | Page |
|---|---|---|
| 0 | Introduction | 139-143 |
| 00 | Evaluation Field Data Statement | 144 |
| J1 | Baseline Data | 145-151 |
| J2 | Accuracy Data | 152-156 |
| J3 | Horizontal Curve Data | 157-159 |
| J4 | Three Station Traverse Data | 160-168 |
| J5 | Four Station Traverse Data | 169-178 |
| J6 | Four and Three Station Traverse Data | 179-198 |
| J7 | Sun Shot Data | 199 |
| J8 | Star Shot Data | 200-205 |
| J9 | Maximum Range Data | 206-209 |
| J10 | Miscellaneous Data | 210-212 |
| J11 | Manual Input Data | 213-215 |
| J12 | Topographic Data | 216-241 |

## APPENDIX J

## AUTOMATED INTEGRATED SURVEYING INSTRUMENTS

## (AISI)

### INTRODUCTION

This appendix contains field data collected during the course of the evaluation. These data are divided into the various activities that were conducted to obtain information necessary to provide the answers to questions posed by agencies that must evaluate the equipment's suitability.

These data are shown in the format that they were collected and processed thus allowing, if desired, an evaluation of the suitability of the format and the processing. The procedures followed in collecting the data have not been detailed as they were normal surveying procedures simply modified to take advantage of the electronic data collection capability. The same is true of the processing procedures inasmuch as they are a "cookbook" type action in that the operator follows instructions presented by the program or the procedure manual. It is possible for the data to be processed by someone who has little knowledge of surveying. However, this presents the possibility that errors could go undetected that would otherwise be detected by the processor. The programs provide the field crew with capability to note errors as they record the data so that during the edit portion of the processing the errors can be corrected. This does not ensure that all errors will be discerned because it is possilble that some errors will be recognized only on the basis of processor output.

The field procedures did not duplicate the performance of every task that has been identified as being required in the topographic and construction survey field. The rationale for this was, that if the equipment can perform the same functional

operation in one area it need not be duplicated in an another. As an example: if the instrument can calculate the differences in elevation for traverse or topographic work then it can do the same for setting grade or drainage layout actions. The function of turning of angles and the measuring of distance is the same no matter what the use made of the information. The accuracy requirements may differ and therefore the more stringent standards were selected. In essence this meant that most procedures were oriented toward topographic standards rather than construction standards.

The basic concept to the field evaluation was that the AISI systems were capable of doing all of the survey tasks required although the procedures were somewhat different. This approach was utilized because of the experience and good use being made of the systems in the commercial surveying field. The field evaluation confirmed that the systems are capable of doing the tasks required and that they do meet the accuracy requirements.

The field evaluation consisted of performing three and four station traverses, taking topographic data, running over a baseline, taking astronomic observations, performing maximum distance measurment, checking field of view, checking stadia constants, performing data transfer (from collector to processor and vice versa), doing data processing, and doing reliability type checks.

In the performance of the traverse functions both a four station and a three station traverse were laid out and the AISI systems were used to run the traverses. These data were collected using the data collectors and processed through the third party computer programs to produce the outputs included as part of this appendix: J4, J5, & J6.

In the performance of the topographic function a series of topographic-type exercises were run to collect data for processing. The data collected were processed

through third party computer programs to the point of assuring that the data could be plotted out on standard plotting equipment. The data and outputs are included as part of this appendix: J12.

The baseline function consisted of running the systems over an established baseline to determine their performance. The baseline consisted of nine stations covering some 900 meters. The data are included as part of this appendix: J1.

The astronomical observations consisted of sun and star shots to verify that the systems were capable of performing the function. In one case sun shots were not taken because there was no way to blank out the distance measuring component so that direct sunlight would not damage the electronics. The data are included as part of the appendix: J7 & J8.

Maximum distance function was checked by shooting a 7 kilometer line to assure that the distance could be achieved. It was found that atmospheric conditions have to be very good to achieve the maximum distance. In the initial attempt one system achieved the distance while the other did not while using the same target prism setup. It was immediately determined by the manufacturer that one system had defective components in another test which had been purchased as being to specification. The manufacturer subsequently provided a replacement instrument containing the correct components and it performed well. The manufacturer is currently in the process of replacing the defective components is those instruments known to contain them. The data are included in the appendix: J9.

The field of view and the stadia constants checks were conducted using normal procedures and found to conform to manufacturers specifications. The data are included in the appendix J10.

A data transfer check was conducted as a part of the normal processing actions in making use of the data collected during traverse and topographic function

evaluation. Data were also entered through the keyboard (manual entry) to verify that such a process could be performed. Data transfer was found to be a straight-forward-relatively-simple process. An important factor noted was that it is necessary to check all transfer settings each time to assure that communication has been established before any attempt is made to transfer the data. As part of the stakeout process curve data were developed on the computer and transfered to the data collector and to the instrument for performing the field layout.

Data processing was done along with data transfer. A majority of the data processing actually occurs automatically. The operator is given options from which to select and then once an option is selected the operator is prompted for key data that is required by the program. This key data are usually available in other files. A critical step in the data processing function is the edit routine. The operator must look for entries made by the field crew that denote errors and then remove them from the data. Because the raw data are not changed the repercussions, of destroying valid data, are lessened. However, the person doing the processing must exercise great caution when in the edit mode. The third party program used in processing was relatively user friendly but does have some areas that need attention. As an example the program requires manual entry of the traverse data (i.e. initial N & E, BS, turned angle, verticle angle, SD) and does not give error of closure. This feature is being evaluated by the maunufacturer. During the data processing the topographic data were used to develope files required by CAD programs to perform plots. These files were transfered (electronically) to the CAD programs and plots produced. This was done to demonstrate that data can be processed all the way through the system.

A type of reliability evaluation was done as part of the field evaluation. This consisted of setting up two triangular layouts and placing the instrument at one of

the points. The instrument was the set up at one of the points and ten angular and distance readings taken. The instrument was then removed from the tripod, placed in its carrying case and carried approximately 10 feet. It was then unpacked and set up on the other tripod. Again 10 measurements were taken. This process was repeated 206 times for each instrument for a total of 2060 trials. Consistency of readings (angular and distance) were the criteria used to determine defects. Of interest was the fact that although the batteries would weaken and have to be replaced the readings remained consistent over the battery's life range. A minor problem occured when one tribrach galled slightly during one of the changeover periods. On-site action cleared the problem with no major loss of time.

Figures 12 & 13 are representative topographic plots as run from a Nicolet plotter using field data from the AISI evaluation.

## APPENDIX J

## FIELD OPERATIONAL AND ENVIRONMENTAL EVALUATION

## (AISI)

## EVALUATION FIELD DATA

This appendix contains Field Data and other information both in arithmetic and pictorial form.

In general the progression of information was as follows:

- o Raw/Field Data
- o Edited Data
- o Data Files; e.g., CAD Program
- o Plotted Data

## EVALUATION FIELD DATA

## APPENDIX J1

## BASELINE DATA

The baseline calculations are provided to record the actual measurements made to the various baseline stations. From these figures the standard deviations were calculated to provide a basis for comparison between what the equipment manufacturer gives as the capability of the equipment and what might be reasonably expected in field performance. The figures used to do the calculations were those collected in the field with the corrections entered into the instrument prior to measurement.

## WILD BASELINE CALCULATIONS

### STANDARD DEVIATIONS

| | LENGTH | RESIDUAL $\nu$ | $\nu^2$ |
|---|---|---|---|
| Sta 0 | 101.197 | -.001 | .000091 |
| to | 101.198 | .000 | |
| Sta 1 | 101.198 | .000 | |
| | 101.198 | .000 | |
| | 101.198 | .000 | |
| | 101.198 | .000 | |
| | 101.198 | .000 | |
| | 101.198 | .000 | |
| | 101.199 | +.001 | .000001 |
| | 101.199 | +.001 | .000001 |
| | 1011.981 | +.001 | .000003 |
| | 101.198 | | |

$$\sigma = \sqrt{\frac{\sum \nu^2}{n-1}}$$

$$\sigma = \pm\sqrt{\frac{.000003}{9}}$$

$$\sigma = \pm .00058 \text{ M}$$

---

| | LENGTH | RESIDUAL $\nu$ | $\nu^2$ |
|---|---|---|---|
| Sta 0 | 201.448 | .000 | |
| to | 201.448 | .000 | |
| Sta 2 | 201.448 | .000 | |
| | 201.447 | -.001 | .000001 |
| | 201.448 | .000 | |
| | 201.446 | -.002 | .000004 |
| | 201.446 | -.002 | .000004 |
| | 201.448 | .000 | |
| | 201.448 | .000 | |
| | 201.448 | .000 | |
| | 2014.475 | -.005 | .000009 |
| | 201.448 | | |

$$\sigma = \pm\sqrt{\frac{.000009}{9}}$$

$$\sigma = \pm .001 \text{ M}$$

---

| | LENGTH | RESIDUAL $\nu$ | $\nu^2$ |
|---|---|---|---|
| Sta 0 | 351.401 | .000 | |
| to | 351.402 | +.001 | .000001 |
| Sta 3 | 351.399 | -.002 | .000004 |
| | 351.400 | -.001 | .000001 |
| | 351.400 | -.001 | .000001 |
| | 351.403 | +.002 | .000004 |
| | 351.401 | .000 | |
| | 351.403 | +.002 | .000004 |
| | 351.401 | .000 | |
| | 351.401 | .000 | |
| | 3514.011 | +.002 | .000015 |
| | 351.401 | | |

$$\sigma = \pm\sqrt{\frac{.000015}{9}}$$

$$\sigma = \pm .0013 \text{ M}$$

| | LENGTH | RESIDUAL $\nu$ | $\nu^2$ | |
|---|---|---|---|---|
| Sta 0 | 501.330 | .000 | | |
| to | 501.330 | .000 | | |
| Sta 4 | 501.330 | .000 | | |
| | 501.331 | +.001 | .000001 | |
| | 501.330 | .000 | | |
| | 501.330 | .000 | | |
| | 501.330 | .000 | | |
| | 501.330 | .000 | | $\sigma = \pm\sqrt{\frac{.000001}{9}}$ |
| | 501.330 | .000 | | |
| | 501.330 | .000 | | |
| | | | | $\sigma = \pm .0003$ M |
| | 5013.301 | .001 | .000001 | |
| | 501.330 | | | |
| Sta 0 | 651.350 | -.001 | .000001 | |
| to | 651.351 | .000 | | |
| Sta 5 | 651.351 | .000 | | |
| | 651.351 | .000 | | |
| | 651.350 | -.001 | .000001 | |
| | 651.351 | .000 | | |
| | 651.351 | .000 | | |
| | 651.350 | -.001 | .000001 | $\sigma = \pm\sqrt{\frac{.000004}{9}}$ |
| | 651.350 | -.001 | .000001 | |
| | 651.351 | .000 | | |
| | | | | $\sigma = \pm .0006$ M |
| | 6413.505 | -.004 | .000004 | |
| | 651.351 | | | |
| Sta 0 | 751.545 | +.001 | .000001 | |
| to | 751.541 | -.003 | .000009 | |
| Sta 7 | 751.541 | -.003 | .000009 | |
| | 751.545 | +.001 | .000001 | |
| | 751.542 | -.002 | .000004 | |
| | 751.545 | +.001 | .000001 | |
| | 751.545 | +.001 | .000001 | |
| | 751.545 | +.001 | .000001 | $\sigma = \pm\sqrt{\frac{.000031}{9}}$ |
| | 751.546 | +.002 | .000004 | |
| | 751.544 | .000 | | |
| | | | | $\sigma = \pm .0019$ M |
| | 7515.439 | -.001 | .000031 | |
| | 751.544 | | | |

| | LENGTH | RESIDUAL $\nu$ | $\nu^2$ | |
|---|---|---|---|---|
| Sta 0 | 851.305 | .000 | .000000 | |
| to | 851.305 | -.000 | .000000 | |
| Sta 851 | 851.303 | -.002 | .000004 | |
| | 851.302 | -.003 | .000009 | |
| | 851.306 | +.001 | .000001 | |
| | 851.307 | +.002 | .000004 | |
| | 851.303 | -.002 | .000004 | |
| | 851.304 | -.001 | .000001 | $\sigma = \pm\sqrt{\frac{.000023}{9}}$ |
| | 851.305 | .000 | .000000 | |
| | 851.305 | .000 | .000000 | |
| | 8513.045 | -.005 | .000023 | $\sigma = \pm\ .00505525$ |
| | 851.305 | | | |

| | LENGTH | RESIDUAL $\nu$ | $\nu^2$ | |
|---|---|---|---|---|
| Sta 0 | 911.297 | .000 | .000000 | |
| to | 911.293 | -.004 | .000016 | |
| Sta 911 | 911.297 | .000 | .000000 | |
| | 911.298 | +.001 | .000001 | |
| | 911.298 | +.001 | .000001 | |
| | 911.297 | .000 | .000000 | |
| | 911.296 | -.001 | .000001 | $\sigma = \pm\sqrt{\frac{.000020}{9}}$ |
| | 911.298 | +.001 | .000001 | |
| | 911.297 | .000 | .000000 | |
| | 9112.968 | -.002 | .000020 | $\sigma = \pm\ .00149071$ |
| | 911.297 | | | |

## GEODIMETER BASELINE CALCULATIONS

### STANDARD DENOTION

| | LENGTH | RESIDUAL $\nu$ | $\nu^2$ |
|---|---|---|---|
| Sta 0 | 101.207 | -.001 | .000001 |
| to | 101.208 | .000 | |
| Sta 1 | 101.209 | +.001 | .000001 |
| | 101.209 | +.001 | .000001 |
| | 101.210 | +.002 | .000004 |
| | 101.209 | +.001 | .000001 |
| | 101.208 | .000 | |
| | 101.207 | -.001 | .000001 |
| | 101.209 | +.001 | .000001 |
| | 101.208 | .000 | |
| | 1012.084 | +.004 | .000010 |

$$\sigma = \pm\sqrt{\frac{\sum \nu^2}{n-1}}$$

$$\sigma = \pm\sqrt{\frac{.000010}{9}}$$

$$\sigma = \pm .00154 \text{ M}$$

101.2084 = 101.208

---

| | LENGTH | RESIDUAL $\nu$ | $\nu^2$ |
|---|---|---|---|
| Sta 0 | 201.452 | .000 | |
| to | 201.451 | -.001 | .000001 |
| Sta 2 | 201.451 | -.001 | .000001 |
| | 201.453 | +.001 | .000001 |
| | 201.452 | .000 | |
| | 201.450 | -.002 | .000004 |
| | 201.452 | .000 | |
| | 201.453 | +.001 | .000001 |
| | 201.451 | -.001 | .000001 |
| | 201.450 | -.002 | .000004 |
| | 2014.517 | -.005 | .000013 |

$$\sigma = \pm\sqrt{\frac{.000013}{9}}$$

$$\sigma = \pm .00120 \text{ M}$$

201.4517 = 201.452

---

| | LENGTH | RESIDUAL $\nu$ | $\nu^2$ |
|---|---|---|---|
| Sta 0 | 351.414 | +.001 | .000001 |
| to | 351.415 | +.002 | .000004 |
| Sta 3 | 351.414 | +.001 | .000001 |
| | 351.414 | +.001 | .000001 |
| | 351.412 | -.001 | .000001 |
| | 351.413 | .001 | |
| | 351.410 | -.003 | .000009 |
| | 351.412 | -.001 | .000001 |
| | 351.411 | -.002 | .000004 |
| | 351.413 | .000 | |
| | 3514.128 | -.002 | .000022 |

$$\sigma = \pm\sqrt{\frac{.000022}{9}}$$

$$\sigma = \pm .00156 \text{ M}$$

351.4128 = 351.413

---

| | LENGTH | RESIDUAL $\nu$ | $\nu^2$ |
|---|---|---|---|
| Sta 0 | 501.339 | +.002 | .000004 |
| to | 501.337 | .000 | |
| Sta 5 | 501.337 | .000 | |
| | 501.338 | +.001 | .000001 |
| | 501.336 | -.001 | .000001 |
| | 501.337 | .000 | |
| | 501.335 | -.002 | .000004 |
| | 501.339 | +.002 | .000004 |
| | 501.337 | .000 | |
| | 501.334 | -.003 | .000009 |
| | 5013.369 | -.001 | .000024 |

501.3369 = 501.337

$$\sigma = \pm\sqrt{\frac{.000025}{9}}$$

$$\sigma = \pm\ .00167 \text{ M}$$

---

| | LENGTH | RESIDUAL $\nu$ | $\nu^2$ |
|---|---|---|---|
| Sta 0 | 651.368 | +.002 | .000004 |
| to | 651.366 | .000 | |
| Sta 6 | 651.367 | +.001 | .000001 |
| | 651.368 | +.002 | .000004 |
| | 651.365 | -.001 | .000001 |
| | 651.365 | -.001 | .000001 |
| | 651.367 | +.001 | .000001 |
| | 651.366 | .000 | |
| | 651.365 | -.001 | .000001 |
| | 651.365 | -.001 | .000001 |
| | 6513.662 | +.002 | .000014 |

651.3662 = 651.366

$$\sigma = \pm\sqrt{\frac{.000014}{9}}$$

$$\sigma = +\ .00125 \text{ M}$$

---

| | LENGTH | RESIDUAL $\nu$ | $\nu^2$ |
|---|---|---|---|
| Sta 0 | 751.553 | -.002 | .000004 |
| to | 751.556 | +.001 | .000001 |
| Sta 7 | 751.557 | +.002 | .000004 |
| | 751.556 | +.001 | .000001 |
| | 751.552 | -.003 | .000009 |
| | 751.556 | +.001 | .000001 |
| | 751.554 | -.001 | .000001 |
| | 751.555 | .000 | |
| | 751.554 | -.001 | .000001 |
| | 751.553 | -.002 | .000004 |
| | 7515.546 | .004 | .000026 |

751.5546 = 751.555

$$\sigma = \pm\sqrt{\frac{.000026}{9}}$$

$$\sigma = \pm\ .00170 \text{ M}$$

| | LENGTH | RESIDUAL $\nu$ | $\nu^2$ |
|---|---|---|---|
| Sta 0 | 854.316 | +.002 | .000004 |
| to | 851.315 | +.001 | .000001 |
| Sta 8 | 851.312 | -.002 | .000004 |
| | 851.313 | -.001 | .000001 |
| | 851.312 | -.002 | .000004 |
| | 851.315 | +.001 | .000001 |
| | 851.315 | +.001 | .000001 |
| | 851.316 | +.002 | .000004 |
| | 851.313 | -.001 | .000001 |
| | 851.315 | +.001 | .000001 |
| | 8513.142 | +.002 | .000022 |

851.3142 = 851.314

$$\sigma = \pm\sqrt{\frac{.000022}{9}}$$

$$\sigma = \pm .00156 \text{ M}$$

| | | | |
|---|---|---|---|
| Sta 0 | 911.313 | +.003 | .000009 |
| to | 911.315 | -.001 | .000001 |
| Sta 9 | 911.315 | -.001 | .000001 |
| | 911.315 | -.001 | .000001 |
| | 911.317 | +.001 | .000001 |
| | 911.314 | -.002 | .000004 |
| | 911.320 | +.003 | .000009 |
| | 911.317 | +.001 | .000001 |
| | 911.317 | +.001 | .000001 |
| | 911.314 | -.002 | .000004 |
| | 9113.157 | +.002 | .000032 |

911.3157 = 911.316

$$\sigma = \pm\sqrt{\frac{.000032}{9}}$$

$$\sigma = \pm .00189 \text{ M}$$

# EVALUATION FIELD DATA

## APPENDIX J2

## ACCURACY DATA

The information contained in this appendix is intended to provide the data necessary to demonstrate the accuracy capability of the instruments while in the horizontal and vertical angle measuring mode. A series, of readings, was taken by three different parties and from this series, of readings, the standard deviations for both horizontal and vertical were calculated. This allows a comparison of the field results and the manufacturers stated capabilities.

WILD H & V PRECISION

| ERROR | | RESIDUAL $\nu$ | $\nu^2$ |
|---|---|---|---|
| 04.40" | .07' | +.02 | .0004 |
| 03.55 | .06 | +.01 | .0001 |
| 03.85 | .06 | +.01 | .0001 |
| 03.45 | .06 | +.01 | .0001 |
| 02.10 | .03 | -.02 | .0004 |
| 02.00 | .03 | -.02 | .0004 |
| 02.50 | .04 | -.01 | .0001 |
| 03.45 | .06 | +.01 | .0001 |
| 01.70 | .03 | -.02 | .0004 |
| 03.10 | .05 | -- | -- |
| 03.90 | .06 | +.01 | .0001 |
| 03.65 | .06 | +.01 | .0001 |
| 03.95 | .06 | +.01 | .0001 |
| 03.85 | .06 | +.01 | .0001 |
| 03.70 | .06 | +.01 | .0001 |
| 03.40 | .06 | +.01 | .0001 |
| 03.65 | .06 | +.01 | .0001 |
| 03.70 | .06 | +.01 | .0001 |
| | 0.97 | = +.07 | = .0019 |

.0013
.0016
.0019

$\frac{0.97}{18} = .05$

$$\sigma = \pm\sqrt{\frac{\sum \nu^2}{n-1}}$$

$$\sigma = \pm\sqrt{\frac{.0019}{17}}$$

$$\sigma = \pm .0106'$$

$$\sigma = .01$$

WILD H & V PRECISION

| ERROR | | RESIDUAL $\nu$ | $\nu^2$ | |
|---|---|---|---|---|
| 00.05" | .00' | -.02 | .0004 | .0032 |
| 01.80 | .03 | +.01 | .0001 | .0007 |
| 01.50 | .03 | +.01 | .0001 | .0016 |
| 01.80 | .03 | +.01 | .0001 | .0055 |
| 02.00 | .03 | +.01 | .0001 | |
| 02.20 | .04 | +.02 | .0004 | |
| 00.00 | .00 | -.02 | .0004 | |
| 00.00 | .00 | -.02 | .0004 | |
| 00.45 | .01 | -.01 | .0001 | |
| 02.20 | .04 | +.02 | .0004 | |
| 01.35 | .02 | -.00 | -- | |
| 03.55 | .06 | +.04 | .0016 | |
| 00.10 | .00 | -.02 | .0004 | |
| 02.40 | .04 | +.02 | .0004 | |
| 00.00 | .00 | -.02 | .0004 | |
| 00.95 | .02 | -.00 | -- | |
| 00.45 | .01 | -.01 | .0001 | |
| 00.55 | .01 | -.01 | .0001 | |
| | 0.37 | = +.01 | = .0055 | |

$= \frac{0.37}{18} = .02$

$$\sigma = \pm\sqrt{\frac{\sum \nu^2}{n-1}}$$

$$\sigma = \pm\sqrt{\frac{.0055}{17}}$$

$$\sigma = \pm .0179'$$

$$\sigma = .02$$

GEODIMETER H & V PRECISION

| ERROR | | RESIDUAL $\nu$ | | $\nu^2$ |
|---|---|---|---|---|
| 03" | 0.05' | -- | | |
| 02 | 0.03 | -.02 | -01 | .0004 |
| 02 | 0.03 | -.02 | -01 | .0004 |
| 04 | 0.07 | +.02 | +01 | .0004 |
| 04 | 0.07 | +.02 | [illegible] | .0004 |
| 03 | 0.05 | -- | -- | -- |
| 02 | 0.03 | -.02 | -01 | .0004 |
| 01 | 0.02 | -.03 | -02 | .0009 |
| 05 | 0.08 | +.03 | +02 | .0009 |
| 06 | 0.10 | +.05 | +03 | .0025 |
| 03 | 0.05 | -- | -- | -- |
| 00 | -- | -- | -- | -- |
| 04.5 | 0.07 | +.02 | +02 | .0004 |
| 04 | 0.07 | +.02 | +01 | .0004 |
| 05 | 0.08 | +.03 | +02 | .0004 |
| 03 | 0.05 | -- | -- | -- |
| 03 | 0.05 | -- | -- | -- |
| 06 | 0.10 | +.05 | +03 | .0025 |
| 60.5 | 1.00 | +1.05 | +10 | .0105 |

$$\frac{60.5}{10} = 03.36 \quad 03.4 = 03''$$

$$\frac{1.00}{18} = .05$$

$$\sigma = \pm\sqrt{\frac{\sum \nu^2}{n-1}}$$

$$\sigma = \pm\sqrt{\frac{.0105}{17}}$$

$$\sigma = \pm .0248'$$

## GEODIMETER H & V PRECISION

| ERROR | | RESIDUAL $\nu$ | $\nu^2$ |
|---|---|---|---|
| 00" | -- ' | | |
| 01 | .02 | | |
| 00 | -- | −.02 | .0004 |
| 01 | .02 | | |
| 02 | .03 | −.02 | .0004 |
| 03 | .05 | −.01 | .0001 |
| 03 | .05 | +.01 | .0001 |
| 05 | .08 | +.01 | .0001 |
| 04 | .07 | +.03 | .0009 |
| 05 | .08 | +.02 | .0004 |
| 03 | .05 | +.03 | .0009 |
| 01 | .02 | +.01 | .0001 |
| 02 | .03 | −.02 | .0004 |
| 03 | .05 | −.01 | .0001 |
| 01 | .02 | +.01 | .0001 |
| 02 | .03 | −.02 | .0004 |
| 02 | .03 | −.01 | .0001 |
| 01.5 | .02 | −.01 | .0001 |
| | 0.65 | −.02 | .0004 |
| | | +0.01 | .0050 |

.0024
.0008
.0018
.0050

$\frac{0.65}{18} = .036 = .04$

$$\sigma = \pm\sqrt{\frac{\sum \nu^2}{n-1}}$$

$$\sigma = \pm\sqrt{\frac{.0050}{17}}$$

$$\sigma = \pm .017'$$

## EVALUATION FIELD DATA

## APPENDIX J3

## HORIZONTAL CURVE DATA

To demonstrate the capability of performing stake-out or layout procedures the data generated by the curve calculation program have been included. These data were generated using software supplied by the equipment manufacturer rather than by the third party software used in other data processing actions. The generated data were then transferred from the computer to the data collector for subsequent transfer to the instrument. It should be noted that it is possible to transfer the data directly to the instrument from the computer if this is considered necessary or expedient. Once the data were transferred to the instrument a series of exercises was run to demonstrate the fact that the instrument could use the transferred data. No problem was encountered during the exercises. A good feature in the use of the stake-out or layout routines is the fact that the instruments read down to zero to allow establishment of line and distance.

STAKEOUT DATA

Instrument Point: 6A Descr: STAKE PC
Back Sight Point: 5 Descr: STAKE #5
Backsight Line: S 77 24 04.4 W

Min. Stakeout Dist: 20.00
Max. Stakeout Dist: 325.00
Hz Angle = Defl

| Point | Direction | Hz Angle | 2x Hz Angle | Hz Dist |
|---|---|---|---|---|
| 5 | S 77 24 04.4 W | -180 00 00.0 | - 00 00 00.0 | 235.94 |
| 6 | S 77 51 16.9 W | -179 32 47.5 | -359 05 35.1 | 35.94 |
| 7 | N 77 12 09.2 E | - 00 11 55.3 | - 00 23 50.6 | 164.06 |
| 6A1 | N 78 13 04.2 E | 00 48 59.7 | 1 37 59.5 | 24.99 |
| 6A2 | N 79 12 17.5 E | 1 48 13.1 | 3 36 26.2 | 49.92 |
| 6A3 | N 80 11 14.4 E | 2 47 10.0 | 5 34 20.0 | 74.71 |
| 6A4 | N 81 09 46.7 E | 3 45 42.3 | 7 31 24.5 | 99.31 |
| 6A5 | N 82 07 46.6 E | 4 43 42.2 | 9 27 24.4 | 123.66 |
| 6A6 | N 83 05 06.9 E | 5 41 02.4 | 11 22 04.7 | 147.69 |
| 6A7 | N 83 36 51.4 E | 6 12 46.9 | 12 25 33.8 | 160.98 |
| 6A8 | N 84 08 35.9 E | 6 44 31.5 | 13 29 03.0 | 174.26 |
| 6A9 | N 85 05 56.1 E | 7 41 51.7 | 15 23 43.3 | 198.20 |
| 6A10 | N 86 03 56.0 E | 8 39 51.6 | 17 19 43.1 | 222.36 |
| 6A11 | N 87 02 28.3 E | 9 38 23.9 | 19 16 47.7 | 246.68 |
| 6A12 | N 88 01 25.2 E | 10 37 20.7 | 21 14 41.5 | 271.10 |
| 6A13 | N 89 00 38.5 E | 11 36 34.1 | 23 13 08.2 | 295.55 |
| 6A14 | N 90 00 00.0 E | 12 35 55.6 | 25 11 51.1 | 319.97 |
| 6B | N 77 18 52.5 E | - 00 05 11.9 | - 00 10 23.9 | 25.00 |
| 6C | N 77 18 52.5 E | - 00 05 11.9 | - 00 10 23.9 | 50.00 |
| 6D | N 77 18 52.5 E | - 00 05 11.9 | - 00 10 23.9 | 75.00 |
| 6E | N 77 18 52.5 E | - 00 05 11.9 | - 00 10 23.9 | 100.00 |
| 6F | N 77 18 52.5 E | - 00 05 11.9 | - 00 10 23.9 | 125.00 |
| 6G | N 77 18 52.5 E | - 00 05 11.9 | - 00 10 23.9 | 150.00 |

| | | | | |
|---|---|---|---|---|
| 7A | N 79 15 27.9 E | 1 51 23.4 | 3 42 46.9 | 175.73 |
| 7B | N 82 06 27.9 E | 4 42 23.4 | 9 24 46.8 | 199.91 |
| 7C | N 84 21 39.7 E | 6 57 35.2 | 13 55 10.5 | 223.49 |
| 7D | N 86 10 55.4 E | 8 46 50.9 | 17 33 41.8 | 247.35 |
| 7E | N 87 40 53.2 E | 10 16 48.8 | 20 33 37.5 | 271.41 |
| 7F | N 88 56 09.3 E | 11 32 04.9 | 23 04 09.8 | 295.63 |
| 7G | N 90 00 00.0 E | 12 35 55.6 | 25 11 51.1 | 319.87 |

## EVALUATION FIELD DATA

## APPENDIX J4

## TRAVERSE DATA

Traverse data are enclosed to demonstrate the fact that the instruments have the capability to measure horizontal and vertical angles and slope distances. In addition the calculation of the error of closure is designed to provide information on the ability of the instrument to meet the requirements of geodetic survey accuracy. The repeated performance of the same three and four station traverses was done to demonstrate the repeatability of the instruments performance. In addition it also provided a check of the consistency of performance by the field crew. The traverses were run in both directions as a cross check of performance. These data are organized in the same manner that it would be in an actual job. It must be noted that the organization, file designations, and available file printouts are dependent on the software in use. The examples given are for the software used in this evaluation. The processing steps and general procedures remain similar between all software. The collected data, called raw data, are stored in the data collector. The data collector is then taken to the computer where the data are transferred to the computer, still in its raw state. Once the raw data are transferred there is a procedure for formatting the data into a file for editing to correct errors made and noted by the field crew or that are discovered during the editing process. The implication that error correcting might provide a means of covering up mistakes or of forcing the data to fit a preconceived solution is not correct. The raw data files cannot be changed. It is possible to destroy the whole file but this in itself is not very probable nor would it be entirely unsuspected. When the editing process is completed there are a number of options open depending on the intended use of the data. In the examples shown the intent was

to determine the error of closure for the traverse and to use that error to determine the corrections to be applied to the traverse. This is done by the software once certain required data are entered into the program. Additional files may be generated to provide interface for various computer aided design programs that will produce the plots for construction task requirements. Examples of the data files used in closing a traverse are shown as labeled.

NOTE: The previous explanation is also applicable for the following appendices:

J5 - Four Station Traverse

J6 - Four and Three Station Traverse

2000

0,50=5

1,7=359.5958

2,8=90.064

3,9=415.723

4,81=40

5,82=1

6,83=3

7,7=335.2614

8,8=90.0726

9,9=499.697

0,81=41

1,82=1

2,83=2

3,7=359.5958

4,8=89.5242

5,9=499.699

6,81=40

7,82=2

8,83=1

9,7=305.08

0,8=89.5604

1,9=211.306

2,81=41

3,82=2

4,83=3

5,7=0

6,8=90.042

7,9=211.307

8,81=40

9,82=3

0,83=2

1,7=259.2602

2,8=89.5306

3,9=415.725

4,81=41

5,82=3

6,83=1

7,81=1

8,82=6

9,83=110687

0,81=20

1,82=0

2,83=0

3,81=21

4,82=5000000

5,83=5000000

6,81=22

7,82=3500000

8,83=2

RETREIVER FORMATTED DATA

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| A0001 | F | 0 | 3595958 | 900640 | 415723 | 415722 | -806 | 3595958 |
| A0002P | F | 1 | 040 040 | 1 | 3 | 00-00 | 1 | 3 |
| A0003 | F | 1 | 3352614 | 900726 | 499697 | 499695 | -1080 | 3352614 |
| A0004P | F | 2 | 041 041 | 1 | 2 | 00-00 | 1 | 2 |
| A0005 | F | 2 | 3595958 | 895242 | 499699 | 499697 | 1061 | 3595958 |
| A0006P | F | 3 | 040 040 | 2 | 1 | 00-00 | 2 | 1 |
| A0007 | F | 3 | 3050800 | 895604 | 211306 | 211305 | 241 | 3050800 |
| A0008P | F | 4 | 041 041 | 2 | 3 | 00-00 | 2 | 3 |
| A0009 | F | 4 | 0 | 900420 | 211307 | 211306 | -266 | 0 |
| A0010P | F | 5 | 040 040 | 3 | 2 | 00-00 | 3 | 2 |
| A0011 | F | 5 | 2592602 | 895306 | 415725 | 415724 | 834 | 2592602 |
| A0012P | F | 6 | 041 041 | 3 | 1 | 00-00 | 3 | 1 |
| A0013P | F | 6 | 001 001 | 6 | 110687 | 00-00 | 6 | 110687 |
| -0014P | F | 1 | 020 020 | 0 | 0 | 00-00 | 0 | 0 |
| -0015P | F | 1 | 021 021 | 5000000 | 5000000 | 00-00 | 5000000 | 5000000 |
| -0016P | F | 1 | 022 022 | 3500000 | 2 | 00-00 | 3500000 | 2 |

ENTER BACKSIGHT AZIMUTH(DDD.MMSS) : 359.5958 TRAVERSE CLOSURE DATA

ENTER TURNED ANGLE(CW): 335.2614

ENTER VERTICAL ANGLE : 90.0726

ENTER SLOPE DISTANCE : 499.697

```
BACKSITE AZIMUTH(DDD.MMSS)=     359.5958
    TURNED ANGLE(DDD.MMSS)=     335.2614
FORESITE AZIMUTH(DDD.MMSS)=     335.2612
  VERTICAL ANGLE(DDD.MMSS)=      90.0726

    HORIZ,VERT,SLOPE DIST =     499.696       -1.081      499.697
CUM HORIZ,VERT,SLOPE DIST =     499.696        1.081      499.697

NRTH,EAST,ELEV THIS POINT = 1107509.000 9460360.000         0.000
NRTH,EAST,ELEV NEXT POINT = 1107963.475 9460152.277        -1.081
```

WOULD YOU LIKE TO PROCEED(P), REDO THIS TRAVERSE POINT(R),
OR BACKUP ONE TRAVERSE POINT(B)?:

TRAVERSE POINT # 2

ENTER TURNED ANGLE(CW): 305.0800

ENTER VERTICAL ANGLE : 89.5604

ENTER SLOPE DISTANCE : 211.306

```
BACKSITE AZIMUTH(DDD.MMSS)=     155.2612
    TURNED ANGLE(DDD.MMSS)=     305.0800
FORESITE AZIMUTH(DDD.MMSS)=     100.3412
  VERTICAL ANGLE(DDD.MMSS)=      89.5604

    HORIZ,VERT,SLOPE DIST =     211.306        0.242      211.306
CUM HORIZ,VERT,SLOPE DIST =     711.002        1.322      711.003

NRTH,EAST,ELEV THIS POINT = 1107963.475 9460152.277        -1.081
NRTH,EAST,ELEV NEXT POINT = 1107924.713 9460359.997        -0.839
```

WOULD YOU LIKE TO PROCEED(P), REDO THIS TRAVERSE POINT(R),
OR BACKUP ONE TRAVERSE POINT(B)?:

```
TRAVERSE POINT #  3

ENTER TURNED ANGLE(CW): 259.26Ø2

ENTER VERTICAL ANGLE  : 89.53Ø6

ENTER SLOPE DISTANCE  : 415.725


BACKSITE AZIMUTH(DDD.MMSS)=    28Ø.3412
    TURNED ANGLE(DDD.MMSS)=    259.26Ø2
FORESITE AZIMUTH(DDD.MMSS)=    18Ø.ØØ14
  VERTICAL ANGLE(DDD.MMSS)=     89.53Ø6

    HORIZ,VERT,SLOPE DIST =     415.724        Ø.834      415.725
CUM HORIZ,VERT,SLOPE DIST =    1126.726        2.157     1126.728

NRTH,EAST,ELEV THIS POINT = 11Ø7924.713 946Ø359.997      -Ø.839
NRTH,EAST,ELEV NEXT POINT = 11Ø75Ø8.989 946Ø359.969      -Ø.ØØ4

WOULD YOU LIKE TO PROCEED(P), REDO THIS TRAVERSE POINT(R),
OR BACKUP ONE TRAVERSE POINT(B)?:
```

TRAVERSE POINT # 1

| | NORTHING | EASTING | ELEVATION | BKSITE AZ |
|---|---|---|---|---|
| UNADJUSTED : | 1107509.000 | 9460360.000 | 0.000 | 359.5958 |
| PROPORTIONAL DISPLACEMENT: | 1107509.000 | 9460360.000 | 0.000 | 359.5958 |

TRAVERSE POINT # 2

| | NORTHING | EASTING | ELEVATION | BKSITE AZ |
|---|---|---|---|---|
| UNADJUSTED : | 1107963.475 | 9460152.277 | -1.081 | 155.2612 |
| PROPORTIONAL DISPLACEMENT: | 1107963.479 | 9460152.291 | -1.079 | 155.26179 |

TRAVERSE POINT # 3

| | NORTHING | EASTING | ELEVATION | BKSITE AZ |
|---|---|---|---|---|
| UNADJUSTED : | 1107924.713 | 9460359.997 | -0.839 | 280.3412 |
| PROPORTIONAL DISPLACEMENT: | 1107924.720 | 9460360.017 | -0.836 | 280.34090 |

DO YOU WISH TO GENERATE A COORDINATE SPEC FILE?:

CALCULATION SHEET - ERROR OF CLOSURE - RETRIEVER SOFTWARE

JOB: Job 5

ORIGIN POINT NORTHING: 1107509.000

UNADJUSTED NORTHING : 1107508.989

NORTHING ERROR: .011

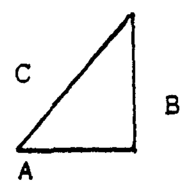
ORIGIN POINT EASTING : 9460360.000

UNADJUSTED EASTING : 9460359.969

EASTING ERROR: .031

DISTANCE: 1126.728

A= .011
B= .031
C= .0330




ERROR OF CLOSURE: 1/ 34,143

This sheet is prepared because the current RETRIEVER software does not calculate the error of closure. The calculations must be done by hand based on next point N and E calculated by the program.

# EVALUATION FIELD DATA

## APPENDIX J5

## FOUR STATION TRAVERSE DATA

2000

0,50=4

1,81=1

2,82=4

3,83=110687

4,81=20

5,82=4290000

6,83=300000

7,81=21

8,82=1267585

9,83=9587494

0,81=22

1,82=41124

2,83=4

3,7=0

4,8=89.3242

5,9=230.541

6,81=40

7,82=1

8,83=4

9,7=329.5132

0,8=89.4556

1,9=376.15

2,81=42

3,82=1

4,83=3

5,7=304.3952

6,8=90.164

7,9=340.59

8,81=41

9,82=1

1,7=359.5958

2,8=89.442

3,9=34Ø.586

4.81=4Ø

5,82=2

6,83=1

7,7=317.5Ø52

8.8=89.1836

9,9=282.561

Ø,81=41

1,82=2

2,83=4

3,7=27Ø.Ø456

4,8=88.5248

5,9=16Ø.159

6,81=41

7,82=2

8,83=3

9,7=.ØØØ4

Ø,8=91.Ø916

1,9=16Ø.163

2,81=4Ø

3,82=3

4,83=2

5,7=295.Ø656

6,8=9Ø.15Ø2

7,9=376.146

8,81=42

9,82=3

Ø,83=1

1,7=261.5356

2,8=89.5556

```
4,81=41
5,82=3
6,83=4
7,7=0
8,8=90.0352
9,9=211.304
0,81=40
1,82=4
2,83=3
3,7=325.522
4,8=90.4234
5,9=282.574
6,81=42
7,82=4
8,83=2
9,7=243.214
0,8=90.2716
1,9=230.546
2,81=41
3,82=4
4,83=1
5,81=1
6,82=5
7,83=110687
8,81=20
9,82=4290000
0,83=300000
1,81=21
2,82=1107509
3,83=9460360
4,81=22
5,82=201548
```

6.83=2

RETREIVER FORMATTED DATA

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| A@@@1P P | 1 | ØØ1 ØØ1 | 4 | 11Ø687 | ØØ-ØØ | 4 | 11Ø687 | |
| -ØØØ2P P | 1 | Ø2Ø Ø2Ø | 429ØØØØ | 3ØØØØØ | ØØ-ØØ | 429ØØØØ | 3ØØØØØ | |
| -ØØØ3P P | 1 | Ø21 Ø21 | 1267585 | 9587494 | ØØ-ØØ | 1267585 | 9587494 | |
| -ØØØ4P P | 1 | Ø22 Ø22 | 41124 | 4 | ØØ-ØØ | 41124 | 4 | |
| -ØØØ5 P | 1 | Ø | 893242 | 23Ø541 | 23Ø533 | 183Ø | Ø | |
| -ØØØ6P P | 2 | Ø4Ø Ø4Ø | 1 | 4 | ØØ-ØØ | 1 | 4 | |
| -ØØØ7 P | 2 | 3295132 | 894556 | 37615Ø | 376146 | 1539 | 3295132 | |
| -ØØØ8P P | 3 | Ø42 Ø42 | 1 | 3 | ØØ-ØØ | 1 | 3 | |
| -ØØØ9 P | 3 | 3Ø43952 | 9Ø164Ø | 34Ø59Ø | 34Ø585 | -1651 | 3Ø43952 | |
| -ØØ1ØP P | 4 | Ø41 Ø41 | 1 | 2 | ØØ-ØØ | 1 | 2 | |
| -ØØ11 P | 4 | 3595958 | 89442Ø | 34Ø586 | 34Ø582 | 1552 | 3595958 | |
| -ØØ12P P | 5 | Ø4Ø Ø4Ø | 2 | 1 | ØØ-ØØ | 2 | 1 | |
| -ØØ13 P | 5 | 3175Ø52 | 891836 | 282561 | 28254Ø | 34Ø2 | 3175Ø52 | |
| -ØØ14P P | 6 | Ø42 Ø42 | 2 | 4 | ØØ-ØØ | 2 | 4 | |
| -ØØ15 P | 6 | 27ØØ456 | 885248 | 16Ø159 | 16Ø128 | 313Ø | 27ØØ456 | |
| -ØØ16P P | 7 | Ø41 Ø41 | 2 | 3 | ØØ-ØØ | 2 | 3 | |
| -ØØ17 P | 7 | 4 | 91Ø916 | 16Ø163 | 16Ø13Ø | -3226 | 4 | |
| -ØØ18P P | 8 | Ø4Ø Ø4Ø | 3 | 2 | ØØ-ØØ | 3 | 2 | |
| -ØØ19 P | 8 | 295Ø656 | 9Ø15Ø2 | 376146 | 376142 | -1644 | 295Ø656 | |
| -ØØ2ØP P | 9 | Ø42 Ø42 | 3 | 1 | ØØ-ØØ | 3 | 1 | |
| -ØØ21 P | 9 | 2615356 | 895556 | 2113Ø4 | 2113Ø3 | 249 | 2615356 | |
| -ØØ22P P | 1Ø | Ø41 Ø41 | 3 | 4 | ØØ-ØØ | 3 | 4 | |
| -ØØ23 P | 1Ø | Ø | 9ØØ352 | 2113Ø4 | 2113Ø3 | -237 | Ø | |
| -ØØ24P P | 11 | Ø4Ø Ø4Ø | 4 | 3 | ØØ-ØØ | 4 | 3 | |
| -ØØ25 P | 11 | 325522Ø | 9Ø4234 | 282574 | 282552 | -3498 | 325522Ø | |
| -ØØ26P P | 12 | Ø42 Ø42 | 4 | 2 | ØØ-ØØ | 4 | 2 | |
| -ØØ27 P | 12 | 243214Ø | 9Ø2716 | 23Ø546 | 23Ø538 | -1828 | 243214Ø | |
| -ØØ28P P | 13 | Ø41 Ø41 | 4 | 1 | ØØ-ØØ | 4 | 1 | |
| -ØØ29P P | 13 | ØØ1 ØØ1 | 5 | 11Ø687 | ØØ-ØØ | 5 | 11Ø687 | |
| -ØØ3ØP P | 1 | Ø2Ø Ø2Ø | 429ØØØØ | 3ØØØØØ | ØØ-ØØ | 429ØØØØ | 3ØØØØØ | |
| -ØØ31P P | 1 | Ø21 Ø21 | 11Ø75Ø9 | 946Ø36Ø | ØØ-ØØ | 11Ø75Ø9 | 946Ø36Ø | |
| -ØØ32P P | 1 | Ø22 Ø22 | 2Ø1548 | 3 | ØØ-ØØ | 2Ø1548 | 3 | |

```
ENTER BACKSIGHT AZIMUTH(DDD.MMSS): 000.0000

ENTER TURNED ANGLE(CW): 304.3952

ENTER VERTICAL ANGLE  : 90.1640

ENTER SLOPE DISTANCE  : 340.590


BACKSITE AZIMUTH(DDD.MMSS)=      0.0000
   TURNED ANGLE(DDD.MMSS)=    304.3952
FORESITE AZIMUTH(DDD.MMSS)=    304.3952
  VERTICAL ANGLE(DDD.MMSS)=     90.1640

    HORIZ,VERT,SLOPE DIST =     340.586       -1.651      340.590
CUM HORIZ,VERT,SLOPE DIST =     340.586        1.651      340.590

NRTH,EAST,ELEV THIS POINT = 1267585.000 9587494.000       0.000
NRTH,EAST,ELEV NEXT POINT = 1267778.715 9587213.869      -1.651


WOULD YOU LIKE TO PROCEED(P), REDO THIS TRAVERSE POINT(R),
OR BACKUP ONE TRAVERSE POINT(B)?:



TRAVERSE POINT #  2

ENTER TURNED ANGLE(CW): 270.0456

ENTER VERTICAL ANGLE  : 88.5248

ENTER SLOPE DISTANCE  : 160.159


BACKSITE AZIMUTH(DDD.MMSS)=    124.3952
   TURNED ANGLE(DDD.MMSS)=    270.0456
FORESITE AZIMUTH(DDD.MMSS)=     34.4448
  VERTICAL ANGLE(DDD.MMSS)=     88.5248

    HORIZ,VERT,SLOPE DIST =     160.128        3.131      160.159
CUM HORIZ,VERT,SLOPE DIST =     500.714        4.782      500.749

NRTH,EAST,ELEV THIS POINT = 1267778.715 9587213.869      -1.651
NRTH,EAST,ELEV NEXT POINT = 1267910.289 9587305.134       1.479


WOULD YOU LIKE TO PROCEED(P), REDO THIS TRAVERSE POINT(R),
OR BACKUP ONE TRAVERSE POINT(B)?:
```

```
TRAVERSE POINT #  3

ENTER TURNED ANGLE(CW): 261.5356

ENTER VERTICAL ANGLE  : 89.5556

ENTER SLOPE DISTANCE  : 211.304


BACKSITE AZIMUTH(DDD.MMSS)=     214.4448
    TURNED ANGLE(DDD.MMSS)=     261.5356
FORESITE AZIMUTH(DDD.MMSS)=     116.3844
  VERTICAL ANGLE(DDD.MMSS)=      89.5556

    HORIZ,VERT,SLOPE DIST =      211.304        0.250      211.304
CUM HORIZ,VERT,SLOPE DIST =      712.018        5.032      712.053

NRTH,EAST,ELEV THIS POINT = 1267910.289 9587305.134        1.479
NRTH,EAST,ELEV NEXT POINT = 1267815.526 9587493.997        1.729

WOULD YOU LIKE TO PROCEED(P), REDO THIS TRAVERSE POINT(R),
OR BACKUP ONE TRAVERSE POINT(B)?:


TRAVERSE POINT #  4

ENTER TURNED ANGLE(CW): 243.2140

ENTER VERTICAL ANGLE  : 90.2716

ENTER SLOPE DISTANCE  : 230.546


BACKSITE AZIMUTH(DDD.MMSS)=     296.3844
    TURNED ANGLE(DDD.MMSS)=     243.2140
FORESITE AZIMUTH(DDD.MMSS)=     180.0024
  VERTICAL ANGLE(DDD.MMSS)=      90.2716

    HORIZ,VERT,SLOPE DIST =      230.539       -1.829      230.546
CUM HORIZ,VERT,SLOPE DIST =      942.557        6.860      942.599

NRTH,EAST,ELEV THIS POINT = 1267815.526 9587493.997        1.729
NRTH,EAST,ELEV NEXT POINT = 1267584.987 9587493.970       -0.099

WOULD YOU LIKE TO PROCEED(P), REDO THIS TRAVERSE POINT(R),
OR BACKUP ONE TRAVERSE POINT(B)?: 9
```

```
PROPORTIONAL DISPLACEMENT:  1267585.000 9587494.000       0.000      0.0000

TRAVERSE POINT #  2
                               NORTHING      EASTING   ELEVATION   BKSITE AZ

UNADJUSTED               :  1267778.715 9587213.869      -1.651    124.3952
PROPORTIONAL DISPLACEMENT:  1267778.720 9587213.880      -1.615    124.3958071

TRAVERSE POINT #  3
                               NORTHING      EASTING   ELEVATION   BKSITE AZ

UNADJUSTED               :  1267910.289 9587305.134       1.479    214.4448
PROPORTIONAL DISPLACEMENT:  1267910.296 9587305.150       1.532    214.4451735

TRAVERSE POINT #  4
                               NORTHING      EASTING   ELEVATION   BKSITE AZ

UNADJUSTED               :  1267815.526 9587493.997       1.729    296.3844
PROPORTIONAL DISPLACEMENT:  1267815.536 9587494.020       1.804    296.3838549

DO YOU WISH TO GENERATE A COORDINATE SPEC FILE?:
```

CALCULATION SHEET - ERROR OF CLOSURE - RETRIEVER SOFTWARE

JOB: Job 4

ORIGIN POINT NORTHING: 1267585.000

UNADJUSTED NORTHING : 1267584.987

NORTHING ERROR: .013

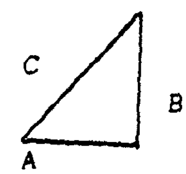
ORIGIN POINT EASTING : 9587494.000

UNADJUSTED EASTING : 9587493.970

EASTING ERROR: .030

DISTANCE: 942.557

A= .013
B= .030
C= .0327




ERROR OF CLOSURE: 1/ 28,824

This sheet is prepared because the current RETRIEVER software does not calculate the error of closure. The calculations must be done by hand based on next point N and E calculated by the program.

## EVALUATION FIELD DATA

## APPENDIX J6

## FOUR AND THREE STATION TRAVERSE DATA

```
410001+00000001 42....+00000004 43....+00270587
410002+00000020 42....+00000429 43....+00000030
410003+00000021 42....+01497505 43....+09604340
410004+00000022 42....+00041124 43....+00000004
110005+00000362 21.104+00000003 22.104+08934254 31..00+00230545 51....+0028+000
410006+00000040 42....+00000001 43....+00000004
110007+00000363 21.104+32951335 22.104+08946220 31..00+00376156 51....+0028+000
410008+00000042 42....+00000003
110009+00000364 21.104+30439509 22.104+09017040 31..00+00340601 51....+0028+000
410010+00000041 42....+00000002
410011+00000020
110012+00000365 21.104+35959595 22.104+08943096 31..00+00340600 51....+0028+000
410013+00000040 42....+00000002 43....+00000001
110014+00000366 21.104+31750524 22.104+08918508 31..00+00282572 51....+0028+000
410015+00000042 42....+00000004
110016+00000367 21.104+27004536 22.104+08851414 31..00+00160162 51....+0028+000
410017+00000041 42....+00000003
410018+00000020
110019+00000368 21.104+35959597 22.104+09108250 31..00+00160163 51....+0028+000
410020+00000040 42....+00000003 43....+00000002
110021+00000369 21.104+29506505 22.104+09014067 31..00+00376158 51....+0028+000
410022+00000042 42....+00000001
110023+00000370 21.104+26153472 22.104+08956371 31..00+00211307 51....+0028+000
410024+00000041 42....+00000004
410025+00000020
110026+00000371 21.104+00000000 22.104+09003365 31..00+00211312 51....+0028+000
410027+00000041 42....+00000004 43....+00000003
410028+00000010
110029+00000372 21.104+00000006 22.104+09003376 31..00+00211313 51....+0028+000
410030+00000040 42....+00000004 43....+00000003
110031+00000373 21.104+32552089 22.104+09041490 31..00+00282569 51....+0028+000
410032+00000042 42....+00000002
110033+00000374 21.104+24321302 22.104+09025502 31..00+00230547 51....+0028+000
410034+00000041 42....+00000001
410035+00000022 42....+01841126
410036+00000001 42....+00000005 43....+00270587
410037+00000020 42....+00000429 43....+00000030
410038+00000021 42....+01107509 43....+09460360
110039+00000375 21.104+35959598 22.104+09007139 31..00+00415732 51....+0028+000
410040+00000040 42....+00000001 43....+00000003
110041+00000376 21.104+33526091 22.104+09007318 31..00+00499706 51....+0028+000
410042+00000041 42....+00000002
410043+00000020
110044+00000377 21.104+35959596 22.104+08952587 31..00+00499710 51....+0028+000
410045+00000040 42....+00000002 43....+00000001
110046+00000378 21.104+30507449 22.104+08956454 31..00+00211313 51....+0028+000
410047+00000041 42....+00000003
410048+00000020
110049+00000379 21.104+35959598 22.104+09003443 31..00+00211312 51....+0028+000
410050+00000040 42....+00000003 43....+00000002
410051+00000010
110052+00000380 21.104+35959597 22.104+09003358 31..00+00211311 51....+0028+000
410053+00000040 42....+00000003 43....+00000002
110054+00000381 21.104+25926023 22.104+08953169 31..00+00415733 51....+0028+000
410055+00000041 42....+00000001
```

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| -0001P | P | 0000001 | 001 001 | 4 | 270587 | 00 00 | 4 | 270587 |
| -0002P | P | 0000001 | 020 020 | 429 | 30 | 00 00 | 429 | 30 |
| -0003P | P | 0000001 | 021 021 | 1497505 | 9604340 | 00 00 | 1497505 | 9604340 |
| -0004P | P | 0000001 | 022 022 | 41124 | 4 | 00 00 | 41124 | 4 |
| -0005 | P | 0000001 | 0000000 | 0893425 | 0230545 | 0230538 | 0001715 | 0000000 |
| -0006P | P | 0000001 | 040 040 | 1 | 4 | 00 00 | 1 | 4 |
| -0007 | P | 0000002 | 3295134 | 0894622 | 0376156 | 0376153 | 0001491 | 3295134 |
| -0008P | P | 0000002 | 042 042 | 3 | | 00 00 | 3 | |
| -0009 | P | 0000003 | 3043951 | 0901704 | 0340601 | 0340596 | -0001691 | 3043951 |
| -0010P | P | 0000003 | 041 041 | 2 | | 00 00 | 2 | |
| -0011P | P | 0000003 | 020 020 | | | 00 00 | | |
| -0012 | P | 0000004 | 3600000 | 0894310 | 0340600 | 0340595 | 0001667 | 3600000 |
| -0013P | P | 0000004 | 040 040 | 2 | 1 | 00 00 | 2 | 1 |
| -0014 | P | 0000005 | 3175052 | 0891851 | 0282572 | 0282551 | 0003382 | 3175052 |
| -0015P | P | 0000005 | 042 042 | 4 | | 00 00 | 4 | |
| -0016 | P | 0000006 | 2700454 | 0885141 | 0160162 | 0160130 | 0003182 | 2700454 |
| -0017P | P | 0000006 | 041 041 | 3 | | 00 00 | 3 | |
| -0018P | P | 0000006 | 020 020 | | | 00 00 | | |
| -0019 | P | 0000007 | 3600000 | 0910825 | 0160163 | 0160131 | -0003188 | 3600000 |
| -0020P | P | 0000007 | 040 040 | 3 | 2 | 00 00 | 3 | 2 |
| -0021 | P | 0000008 | 2950651 | 0901407 | 0376158 | 0376154 | -0001545 | 2950651 |
| -0022P | P | 0000008 | 042 042 | 1 | | 00 00 | 1 | |
| -0023 | P | 0000009 | 2615347 | 0895637 | 0211307 | 0211306 | 0000208 | 2615347 |
| -0024P | P | 0000009 | 041 041 | 4 | | 00 00 | 4 | |
| -0025P | P | 0000009 | 020 020 | | | 00 00 | | |
| -0026 | P | 0000010 | 0000000 | 0900337 | 0211312 | 0211311 | -0000223 | 0000000 |
| -0027P | P | 0000010 | 041 041 | 4 | 3 | 00 00 | 4 | 3 |
| -0028P | P | 0000010 | 010 010 | | | 00 00 | | |
| -0029 | P | 0000011 | 0000001 | 0900338 | 0211313 | 0211312 | -0000224 | 0000001 |
| -0030P | P | 0000011 | 040 040 | 4 | 3 | 00 00 | 4 | 3 |
| -0031 | P | 0000012 | 3255209 | 0904149 | 0282569 | 0282548 | -0003437 | 3255209 |
| -0032P | P | 0000012 | 042 042 | 2 | | 00 00 | 2 | |
| -0033 | P | 0000013 | 2432130 | 0902550 | 0230547 | 0230540 | -0001733 | 2432130 |
| -0034P | P | 0000013 | 041 041 | 1 | | 00 00 | 1 | |
| -0035P | P | 0000013 | 022 022 | 1841126 | | 00 00 | 1841126 | |
| -0036P | P | 0000013 | 001 001 | 5 | 270587 | 00 00 | 5 | 270587 |
| -0037P | P | 0000013 | 020 020 | 429 | 30 | 00 00 | 429 | 30 |
| -0038P | P | 0000013 | 021 021 | 1107509 | 9460360 | 00 00 | 1107509 | 9460360 |
| -0039 | P | 0000014 | 3600000 | 0900714 | 0415732 | 0415731 | -0000875 | 3600000 |
| -0040P | P | 0000014 | 040 040 | 1 | 3 | 00 00 | 1 | 3 |
| -0041 | P | 0000015 | 3352609 | 0900732 | 0499706 | 0499704 | -0001095 | 3352609 |
| -0042P | P | 0000015 | 041 041 | 2 | | 00 00 | 2 | |
| -0043P | P | 0000015 | 020 020 | | | 00 00 | | |
| -0044 | P | 0000016 | 3600000 | 0895259 | 0499710 | 0499708 | 0001020 | 3600000 |
| -0045P | P | 0000016 | 040 040 | 2 | 1 | 00 00 | 2 | 1 |
| -0046 | P | 0000017 | 3050745 | 0895645 | 0211313 | 0211312 | 0000199 | 3050745 |
| -0047P | P | 0000017 | 041 041 | 3 | | 00 00 | 3 | |
| -0048P | P | 0000017 | 020 020 | | | 00 00 | | |
| -0049 | P | 0000018 | 3595959 | 0900344 | 0211312 | 0211311 | -0000230 | 3595959 |
| -0050P | P | 0000018 | 040 040 | 3 | 2 | 00 00 | 3 | 2 |
| -0051P | P | 0000018 | 010 010 | | | 00 00 | | |
| -0052 | P | 0000019 | 3600000 | 0900336 | 0211311 | 0211310 | -0000222 | 3600000 |
| -0053P | P | 0000019 | 040 040 | 3 | 2 | 00 00 | 3 | 2 |
| -0054 | P | 0000020 | 2592602 | 0895317 | 0415733 | 0415732 | 0000812 | 2592602 |
| -0055P | P | 0000020 | 041 041 | 1 | | 00 00 | 1 | |

```
ENTER BACKSIGHT AZIMUTH(DDD.MMSS): 000.0000

ENTER TURNED ANGLE(CW): 304.3951

ENTER VERTICAL ANGLE  : 90.1704

ENTER SLOPE DISTANCE  : 340.601


BACKSITE AZIMUTH(DDD.MMSS)=       0.0000
    TURNED ANGLE(DDD.MMSS)=     304.3951
FORESITE AZIMUTH(DDD.MMSS)=     304.3951
  VERTICAL ANGLE(DDD.MMSS)=      90.1704

    HORIZ,VERT,SLOPE DIST =      340.597      -1.691      340.601
CUM HORIZ,VERT,SLOPE DIST =      340.597       1.691      340.601

NRTH,EAST,ELEV THIS POINT = 1497505.000 9604340.000        0.000
NRTH,EAST,ELEV NEXT POINT = 1497698.720 9604059.859       -1.691


WOULD YOU LIKE TO PROCEED(P), REDO THIS TRAVERSE POINT(R),
OR BACKUP ONE TRAVERSE POINT(B)?:



TRAVERSE POINT #  2

ENTER TURNED ANGLE(CW): 270.0454

ENTER VERTICAL ANGLE  : 88.5141

ENTER SLOPE DISTANCE  : 160.162


BACKSITE AZIMUTH(DDD.MMSS)=     124.3951
    TURNED ANGLE(DDD.MMSS)=     270.0454
FORESITE AZIMUTH(DDD.MMSS)=      34.4445
  VERTICAL ANGLE(DDD.MMSS)=      88.5141

    HORIZ,VERT,SLOPE DIST =      160.130       3.183      160.162
CUM HORIZ,VERT,SLOPE DIST =      500.727       4.874      500.763

NRTH,EAST,ELEV THIS POINT = 1497698.720 9604059.859       -1.691
NRTH,EAST,ELEV NEXT POINT = 1497830.297 9604151.123        1.492


WOULD YOU LIKE TO PROCEED(P), REDO THIS TRAVERSE POINT(R),
OR BACKUP ONE TRAVERSE POINT(B)?:
```

```
TRAVERSE POINT #  3

ENTER TURNED ANGLE(CW): 261.5347

ENTER VERTICAL ANGLE  : 89.5637

ENTER SLOPE DISTANCE  : 211.307


BACKSITE AZIMUTH(DDD.MMSS)=    214.4445
    TURNED ANGLE(DDD.MMSS)=    261.5347
FORESITE AZIMUTH(DDD.MMSS)=    116.3832
  VERTICAL ANGLE(DDD.MMSS)=     89.5637

    HORIZ,VERT,SLOPE DIST =     211.307       0.208     211.307
CUM HORIZ,VERT,SLOPE DIST =     712.034       5.081     712.070

NRTH,EAST,ELEV THIS POINT = 1497830.297 9604151.123        1.492
NRTH,EAST,ELEV NEXT POINT = 1497735.543 9604339.995        1.700


WOULD YOU LIKE TO PROCEED(P), REDO THIS TRAVERSE POINT(R),
OR BACKUP ONE TRAVERSE POINT(B)?:


TRAVERSE POINT #  4

ENTER TURNED ANGLE(CW): 243.2130

ENTER VERTICAL ANGLE  : 90.2550

ENTER SLOPE DISTANCE  : 230.547


BACKSITE AZIMUTH(DDD.MMSS)=    296.3832
    TURNED ANGLE(DDD.MMSS)=    243.2130
FORESITE AZIMUTH(DDD.MMSS)=    180.0002
  VERTICAL ANGLE(DDD.MMSS)=     90.2550

    HORIZ,VERT,SLOPE DIST =     230.540      -1.732     230.547
CUM HORIZ,VERT,SLOPE DIST =     942.575       6.814     942.617

NRTH,EAST,ELEV THIS POINT = 1497735.543 9604339.995        1.700
NRTH,EAST,ELEV NEXT POINT = 1497505.003 9604339.992       -0.033


WOULD YOU LIKE TO PROCEED(P), REDO THIS TRAVERSE POINT(R),
OR BACKUP ONE TRAVERSE POINT(B)?:
```

```
PROPORTIONAL DISPLACEMENT:  1497505.000 9604740.000        0.000       0.0000

TRAVERSE POINT #  2
                              NORTHING     EASTING    ELEVATION    BKSITE AZ

UNADJUSTED               :  1497698.720 9604059.859      -1.691    124.3951
PROPORTIONAL DISPLACEMENT:  1497698.719 9604059.862      -1.679    124.39514

TRAVERSE POINT #  3
                              NORTHING     EASTING    ELEVATION    BKSITE AZ

UNADJUSTED               :  1497830.297 9604151.123       1.492    214.4445
PROPORTIONAL DISPLACEMENT:  1497830.296 9604151.127       1.509    214.44466

TRAVERSE POINT #  4
                              NORTHING     EASTING    ELEVATION    BKSITE AZ

UNADJUSTED               :  1497735.543 9604339.995       1.700    296.3832
PROPORTIONAL DISPLACEMENT:  1497735.541 9604340.000       1.724    296.383179

DO YOU WISH TO GENERATE A COORDINATE SPEC FILE?:
```

CALCULATION SHEET - ERROR OF CLOSURE - RETRIEVER SOFTWARE

JOB: May 2

ORIGIN POINT NORTHING: 1497505.000

UNADJUSTED NORTHING : 1497505.003

NORTHING ERROR: .003

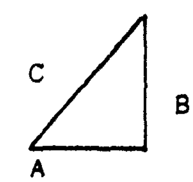
ORIGIN POINT EASTING : 9604340.000

UNADJUSTED EASTING : 9604339.992

EASTING ERROR: .008

DISTANCE: 942.575

A= .003
B= .008
C= .0085




ERROR OF CLOSURE: 1/ 110,891

This sheet is prepared because the current RETRIEVER softwar does not calculate the error of closure. The calculations must b done by hand based on next point N and E calculated by th program.

```
ENTER BACKSIGHT AZIMUTH(DDD.MMSS): 000.0000

ENTER TURNED ANGLE(CW): 335.2609

ENTER VERTICAL ANGLE  : 90.0732

ENTER SLOPE DISTANCE  : 499.706


BACKSITE AZIMUTH(DDD.MMSS)=       0.0000
    TURNED ANGLE(DDD.MMSS)=     335.2609
FORESITE AZIMUTH(DDD.MMSS)=     335.2609
  VERTICAL ANGLE(DDD.MMSS)=      90.0732

    HORIZ,VERT,SLOPE DIST =      499.705       -1.095      499.706
CUM HORIZ,VERT,SLOPE DIST =      499.705        1.095      499.706

NRTH,EAST,ELEV THIS POINT = 1107509.000 9460360.000        0.000
NRTH,EAST,ELEV NEXT POINT = 1107963.480 9460152.267       -1.095


WOULD YOU LIKE TO PROCEED(P), REDO THIS TRAVERSE POINT(R),
OR BACKUP ONE TRAVERSE POINT(B)?:



TRAVERSE POINT #  2

ENTER TURNED ANGLE(CW): 305.0745

ENTER VERTICAL ANGLE  : 89.5645

ENTER SLOPE DISTANCE  : 211.313


BACKSITE AZIMUTH(DDD.MMSS)=     155.2609
    TURNED ANGLE(DDD.MMSS)=     305.0745
FORESITE AZIMUTH(DDD.MMSS)=     100.3354
  VERTICAL ANGLE(DDD.MMSS)=      89.5645

    HORIZ,VERT,SLOPE DIST =      211.313        0.200      211.313
CUM HORIZ,VERT,SLOPE DIST =      711.018        1.295      711.019

NRTH,EAST,ELEV THIS POINT = 1107963.480 9460152.267       -1.095
NRTH,EAST,ELEV NEXT POINT = 1107924.735 9460359.997       -0.895


WOULD YOU LIKE TO PROCEED(P), REDO THIS TRAVERSE POINT(R),
OR BACKUP ONE TRAVERSE POINT(B)?:
```

```
TRAVERSE POINT #  3

ENTER TURNED ANGLE(CW): 259.2602

ENTER VERTICAL ANGLE  : 89.5317

ENTER SLOPE DISTANCE  : 415.733


BACKSITE AZIMUTH(DDD.MMSS)=    280.3354
    TURNED ANGLE(DDD.MMSS)=    259.2602
FORESITE AZIMUTH(DDD.MMSS)=    179.5956
  VERTICAL ANGLE(DDD.MMSS)=     89.5317

    HORIZ,VERT,SLOPE DIST =     415.732        0.812     415.733
CUM HORIZ,VERT,SLOPE DIST =    1126.750        2.107    1126.752

NRTH,EAST,ELEV THIS POINT = 1107924.735 9460359.997       -0.895
NRTH,EAST,ELEV NEXT POINT = 1107509.003 9460360.005       -0.083


WOULD YOU LIKE TO PROCEED(P), REDO THIS TRAVERSE POINT(R),
OR BACKUP ONE TRAVERSE POINT(B)": P
```

CALCULATION SHEET - ERROR OF CLOSURE - RETRIEVER SOFTWARE

JOB: May 2

ORIGIN POINT NORTHING: 1107509.000

UNADJUSTED NORTHING : 1107509.003

NORTHING ERROR: .003

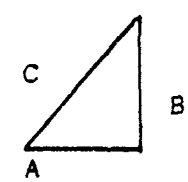
ORIGIN POINT EASTING : 9460360.000

UNADJUSTED EASTING : 9460360.005

EASTING ERROR: .005

DISTANCE: 1126.750

A= .003
B= .005
C= .0058




ERROR OF CLOSURE: 1/ 194,267

This sheet is prepared because the current RETRIEVER softwar does not calculate the error of clcsure. The calculations must b done by hand based on next point N and E calculated by th program.

# RETREIVER FORMATTED DATA

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| -ØØØ1P | P | ØØØØØØ1 | ØØ1 ØØ1 | 4 | 26Ø587 | ØØ ØØ | 4 | 26Ø587 |
| -ØØØ1P | PØ1 | ØØØØØØ2 | Ø2Ø Ø2Ø | 14975Ø5 | 96Ø443Ø | ØØ ØØ | 14975Ø5 | 96Ø443Ø |
| -ØØØ2 | P | ØØØØØØ1 | 36ØØØØØ | Ø9Ø2624 | Ø23Ø548 | Ø23Ø541 | -ØØØ1771 | 36ØØØØØ |
| -ØØØ3P | P | ØØØØØØ1 | Ø4Ø Ø4Ø | 4 | 1 | ØØ ØØ | 4 | 1 |
| -ØØØ4 | P | ØØØØØØ2 | Ø823Ø43 | Ø9Ø4126 | Ø28257Ø | Ø282549 | -ØØØ34Ø6 | Ø823Ø43 |
| -ØØØ5P | P | ØØØØØØ2 | Ø42 Ø42 | 2 | | ØØ ØØ | 2 | |
| -ØØØ6 | P | ØØØØØØ3 | 1163836 | Ø9ØØ427 | Ø21135Ø | Ø211349 | -ØØØØ274 | 1163836 |
| -ØØØ6P | PØ1 | ØØØØØØ7 | Ø4Ø Ø4Ø | | | ØØ ØØ | | |
| -ØØØ6P | PØ1 | ØØØØØØ7 | Ø4Ø Ø4Ø | | | ØØ ØØ | | |
| -ØØØ6P | PØ1 | ØØØØØØ7 | Ø2Ø Ø2Ø | Ø | Ø | ØØ ØØ | Ø | Ø |
| -ØØØ7P | P | ØØØØØØ3 | Ø41 Ø41 | 3 | | ØØ ØØ | 3 | |
| -ØØØ8 | P | ØØØØØØ4 | 36ØØØØØ | Ø895755 | Ø2113Ø9 | Ø2113Ø8 | ØØØØ128 | 36ØØØØØ |
| -ØØØ9P | P | ØØØØØØ4 | Ø4Ø Ø4Ø | 3 | 4 | ØØ ØØ | 3 | 4 |
| -ØØ1Ø | P | ØØØØØØ5 | Ø3313Ø3 | Ø9Ø1431 | Ø37616Ø | Ø376156 | -ØØØ1589 | Ø3313Ø3 |
| -ØØ11P | P | ØØØØØØ5 | Ø42 Ø42 | 1 | | ØØ ØØ | 1 | |
| -ØØ12 | P | ØØØØØØ6 | Ø98Ø6Ø7 | Ø91Ø826 | Ø16Ø172 | Ø16Ø14Ø | -ØØØ3189 | Ø98Ø6Ø7 |
| -ØØ13P | P | ØØØØØØ6 | Ø41 Ø41 | 2 | | ØØ ØØ | 2 | |
| -ØØ13P | PØ1 | ØØØØØØ2 | Ø2Ø Ø2Ø | Ø | Ø | ØØ ØØ | Ø | Ø |
| -ØØ13 | PXX | ØØØØØØ7 | ØØØØØØØ | ØØØØØØØ | ØØØØØØØ | ØØØØØØØ | ØØØØØØØ | ØØØØØØØ |
| -ØØ14 | P | ØØØØØØ7 | 36ØØØØØ | Ø885258 | Ø16Ø198 | Ø16Ø167 | ØØØ3123 | 36ØØØØØ |
| -ØØ15P | P | ØØØØØØ7 | Ø4Ø Ø4Ø | 2 | 3 | ØØ ØØ | 2 | 3 |
| -ØØ16 | P | ØØØØØØ8 | Ø474558 | Ø892ØØ2 | Ø28257Ø | Ø28255Ø | ØØØ3285 | Ø474558 |
| -ØØ17P | P | ØØØØØØ8 | Ø42 Ø42 | 4 | | ØØ ØØ | 4 | |
| -ØØ18 | P | ØØØØØØ9 | Ø8955Ø8 | Ø894357 | Ø3406Ø3 | Ø34Ø599 | ØØØ159Ø | Ø8955Ø8 |
| -ØØ19P | P | ØØØØØØ9 | Ø41 Ø41 | 1 | | ØØ ØØ | 1 | |
| -ØØ19P | PØ1 | ØØØØØØ1 | Ø2Ø Ø2Ø | Ø | Ø | ØØ ØØ | Ø | Ø |
| -ØØ2Ø | P | ØØØØØ1Ø | 36ØØØØØ | Ø9Ø1722 | Ø3406ØØ | Ø34Ø595 | -ØØØ1721 | 36ØØØØØ |
| -ØØ21P | P | ØØØØØ1Ø | Ø4Ø Ø4Ø | 1 | 2 | ØØ ØØ | 1 | 2 |
| -ØØ22 | P | ØØØØØ11 | Ø251141 | Ø894654 | Ø376196 | Ø376193 | ØØØ1433 | Ø251141 |
| -ØØ23P | P | ØØØØØ11 | Ø42 Ø42 | 3 | | 1Ø ØØ | 3 | |
| -ØØ24 | P | ØØØØØ12 | Ø552ØØ3 | Ø893543 | Ø23Ø551 | Ø23Ø545 | ØØØ1628 | Ø552ØØ3 |
| -ØØ25P | P | ØØØØØ12 | Ø41 Ø41 | 4 | | ØØ ØØ | 4 | |
| -ØØ26P | P | ØØØØØ12 | ØØ1 ØØ1 | 5 | 26Ø587 | - ØØ ØØ | 5 | 26Ø587 |
| -ØØ26P | PØ1 | ØØØØØØ1 | Ø2Ø Ø2Ø | 11Ø75Ø9 | 946Ø36Ø | ØØ ØØ | 11Ø75Ø9 | 946Ø36Ø |
| -ØØ27 | P | ØØØØØ13 | 36ØØØØØ | Ø9ØØ8Ø1 | Ø499751 | Ø499749 | -ØØØ1166 | 36ØØØØØ |
| -ØØ28P | P | ØØØØØ13 | Ø4Ø Ø4Ø | 1 | 2 | ØØ ØØ | 1 | 2 |
| -ØØ29 | P | ØØØØØ14 | Ø243349 | Ø9ØØ8Ø3 | Ø415741 | Ø415739 | -ØØØØ974 | Ø243349 |
| -ØØ3ØP | P | ØØØØØ14 | Ø41 Ø41 | 3 | | ØØ ØØ | 3 | |
| -ØØ3ØP | PØ1 | ØØØØØØ3 | Ø2Ø Ø2Ø | | | ØØ ØØ | | |
| -ØØ31 | P | ØØØØØ15 | 36ØØØØØ | Ø8953Ø7 | Ø415772 | Ø415771 | ØØØØ832 | 36ØØØØØ |
| -ØØ32P | P | ØØØØØ15 | Ø4Ø Ø4Ø | 3 | 1 | ØØ ØØ | 3 | 1 |
| -ØØ33 | P | ØØØØØ16 | 1ØØ34Ø2 | Ø9ØØ356 | Ø211348 | Ø211347 | -ØØØØ242 | 1ØØ34Ø2 |
| -ØØ34P | P | ØØØØØ16 | Ø41 Ø41 | 2 | | ØØ ØØ | 2 | |
| -ØØ34P | PØ1 | ØØØØØØ2 | Ø2Ø Ø2Ø | | | ØØ ØØ | | |
| -ØØ35 | P | ØØØØØ17 | ØØØØØØØ | Ø895754 | Ø211313 | Ø211312 | ØØØØ129 | ØØØØØØØ |
| -ØØ36P | P | ØØØØØ17 | Ø4Ø Ø4Ø | 2 | 3 | ØØ ØØ | 2 | 3 |
| -ØØ37 | P | ØØØØØ18 | Ø545155 | Ø895315 | Ø499748 | Ø499747 | ØØØØ981 | Ø545155 |
| -ØØ38P | P | ØØØØØ18 | Ø41 Ø41 | 1 | | ØØ ØØ | 1 | |

## RAW DATA

```
410001+00000001 42....+00000004 43....+00260587
110002+00000344 21.104+35959598 22.104+09026237 31..00+00230548 51....+0050+030
410003+00000040 42....+00000004 43....+00000001
110004+00000345 21.104+08230428 22.104+09041261 31..00+00282570 51....-0050+030
410005+00000042 42....+00000002
110006+00000346 21.104+11638360 22.104+09004270 31..00+00211350 51....+0050+030
410007+00000041 42....+00000003
110008+00000347 21.104+35959597 22.104+08957547 31..00+00211309 51....+0050+030
410009+00000040 42....+00000003 43....+00000004
110010+00000348 21.104+03313033 22.104+09014310 31..00+00376160 51....+0050+030
410011+00000042 42....+00000001
110012+00000349 21.104+09806067 22.104+09109260 31..00+00160172 51....+0050+030
410013+00000041 42....+00000002
110014+00000350 21.104+35959599 22.104+08852581 31..00+00160198 51....+0050+030
410015+00000040 42....+00000002 43....+00000003
110016+00000351 21.104+04745577 22.104+08920017 31..00+00282570 51....+0050+030
410017+00000042 42....+00000004
110018+00000352 21.104+08955079 22.104+08943570 31..00+00340603 51....+0050+030
410019+00000041 42....+00000001
110020+00000353 21.104+35959595 22.104+09017222 31..00+00340600 51....+0050+030
410021+00000040 42....+00000001 43....+00000002
110022+00000354 21.104+02511412 22.104+08946540 31..00+00376196 51....+0050+030
410023+00000042 42....+00000003
110024+00000355 21.104+05520033 22.104+08935430 31..00+00230551 51....+0050+030
410025+00000041 42....+00000004
410026+00000001 42....+00000005 43....+00260587
110027+00000356 21.104+35959596 22.104+09008009 31..00+00499751 51....+0050+030
410028+00000040 42....+00000001 43....+00000002
110029+00000357 21.104+02433493 22.104+09008030 31..00+00415741 51....+0050+030
410030+00000041 42....+00000003
110031+00000358 21.104+35959598 22.104+08953072 31..00+00415772 51....+0050+030
410032+00000040 42....+00000003 43....+00000001
110033+00000359 21.104+10034024 22.104+09003558 31..00+00211348 51....+0050+030
410034+00000041 42....+00000002
110035+00000360 21.104+00000000 22.104+08957543 31..00+00211313 51....+0050+030
410036+00000040 42....+00000002 43....+00000003
110037+00000361 21.104+05451554 22.104+08953154 31..00+00499748 51....+0050+030
410038+00000041 42....+00000001
```

TRAVERSE CLOSURE DATA

HORIZONTAL & VERTICAL TRAVERSE COMPUTATION & CLOSURE

```
DO YOU INTEND TO CLOSE THE TRAVERSE?: Y


DO YOU WISH TO USE LEAST SQUARES?: N


IS THE TRAVERSE OPEN (O) OR CLOSED (C)?: C

ENTER NUMBER OF TRAVERSE POINTS: 3

ENTER BACKSIGHT AZIMUTH(DDD.MMSS): 000.0000

ENTER TURNED ANGLE(CW): 024.3349

ENTER VERTICAL ANGLE  : 90.0803

ENTER SLOPE DISTANCE  : 415.739

BACKSITE AZIMUTH(DDD.MMSS)=      0.0000
    TURNED ANGLE(DDD.MMSS)=     24.3349
FORESITE AZIMUTH(DDD.MMSS)=     24.3349
  VERTICAL ANGLE(DDD.MMSS)=     90.0803

    HORIZ,VERT,SLOPE DIST =     415.738        -0.974      415.739
CUM HORIZ,VERT,SLOPE DIST =     415.738         0.974      415.739

NRTH,EAST,ELEV THIS POINT = 1107509.000 9460360.000          0.000
NRTH,EAST,ELEV NEXT POINT = 1107887.114 9460532.824         -0.974

WOULD YOU LIKE TO PROCEED(P), REDO THIS TRAVERSE POINT(R),
OR BACKUP ONE TRAVERSE POINT(B)?:
```

```
TRAVERSE POINT #  2

ENTER TURNED ANGLE(CW): 1ØØ.34Ø2

ENTER VERTICAL ANGLE  : 9Ø.Ø356

ENTER SLOPE DISTANCE  : 211.348


BACKSITE AZIMUTH(DDD.MMSS)=    2Ø4.3349
    TURNED ANGLE(DDD.MMSS)=    1ØØ.34Ø2
FORESITE AZIMUTH(DDD.MMSS)=    3Ø5.Ø751
  VERTICAL ANGLE(DDD.MMSS)=     9Ø.Ø356

    HORIZ,VERT,SLOPE DIST =     211.348       -Ø.242      211.348
CUM HORIZ,VERT,SLOPE DIST =     627.Ø86        1.215      627.Ø87

NRTH,EAST,ELEV THIS POINT = 11Ø7887.114 946Ø532.824       -Ø.974
NRTH,EAST,ELEV NEXT POINT = 11Ø8ØØ8.733 946Ø359.975       -1.215


WOULD YOU LIKE TO PROCEED(P), REDO THIS TRAVERSE POINT(R),
OR BACKUP ONE TRAVERSE POINT(B)?:


TRAVERSE POINT #  3

ENTER TURNED ANGLE(CW): Ø54.5155

ENTER VERTICAL ANGLE  : 89.5315

ENTER SLOPE DISTANCE  : 499.748


BACKSITE AZIMUTH(DDD.MMSS)=    125.Ø751
    TURNED ANGLE(DDD.MMSS)=     54.5155
FORESITE AZIMUTH(DDD.MMSS)=    179.5946
  VERTICAL ANGLE(DDD.MMSS)=     89.5315

    HORIZ,VERT,SLOPE DIST =     499.747        Ø.981      499.748
CUM HORIZ,VERT,SLOPE DIST =    1126.833        2.197     1126.835

NRTH,EAST,ELEV THIS POINT = 11Ø8ØØ8.733 946Ø359.975       -1.215
NRTH,EAST,ELEV NEXT POINT = 11Ø75Ø8.986 946Ø36Ø.ØØ9       -Ø.234


WOULD YOU LIKE TO PROCEED(P), REDO THIS TRAVERSE POINT(R),
OR BACKUP ONE TRAVERSE POINT(B)?:
```

TRAVERSE POINT # 1

| | NORTHING | EASTING | ELEVATION | BKSITE A |
|---|---|---|---|---|
| UNADJUSTED : | 1107509.000 | 9460360.000 | 0.000 | 0.0000 |
| PROPORTIONAL DISPLACEMENT: | 1107509.000 | 9460360.000 | 0.000 | 0.0000 |

TRAVERSE POINT # 2

| | NORTHING | EASTING | ELEVATION | BKSITE A |
|---|---|---|---|---|
| UNADJUSTED : | 1107887.114 | 9460532.824 | -0.974 | 204.3349 |
| PROPORTIONAL DISPLACEMENT: | 1107887.119 | 9460532.820 | -0.887 | 204.334645 |

TRAVERSE POINT # 3

| | NORTHING | EASTING | ELEVATION | BKSITE A |
|---|---|---|---|---|
| UNADJUSTED : | 1108008.733 | 9460359.975 | -1.215 | 125.0751 |
| PROPORTIONAL DISPLACEMENT: | 1108008.741 | 9460359.970 | -1.085 | 125.075221 |

DO YOU WISH TO GENERATE A COORDINATE SPEC FILE?:

TRAVERSE CLOSURE DATA

```
IS THE TRAVERSE OPEN (O) OR CLOSED (C)?: C


ENTER NUMBER OF TRAVERSE POINTS: 4


TRAVERSE POINT #  1

ENTER NORTHING: 1497505

ENTER EASTING : 9604340

ENTER H.I.    : 0

ENTER BACKSIGHT AZIMUTH(DDD.MMSS): 000.0000


ENTER TURNED ANGLE(CW): 304.3951

ENTER VERTICAL ANGLE  : 90.1704

ENTER SLOPE DISTANCE  : 340.601


ENTER BACKSIGHT AZIMUTH(DDD.MMSS): 000.0000


ENTER TURNED ANGLE(CW): 304.3951

ENTER VERTICAL ANGLE  : 90.1704

ENTER SLOPE DISTANCE  : 340.601


BACKSITE AZIMUTH(DDD.MMSS)=      0.0000
    TURNED ANGLE(DDD.MMSS)=    304.3951
FORESITE AZIMUTH(DDD.MMSS)=    304.3951
  VERTICAL ANGLE(DDD.MMSS)=     90.1704

    HORIZ,VERT,SLOPE DIST =     340.597       -1.691      340.601
CUM HORIZ,VERT,SLOPE DIST =     340.597        1.691      340.601

NRTH,EAST,ELEV THIS POINT = 1497505.000 9604340.000        0.000
NRTH,EAST,ELEV NEXT POINT = 1497698.720 9604059.859       -1.691


WOULD YOU LIKE TO PROCEED(P), REDO THIS TRAVERSE POINT(R),
OR BACKUP ONE TRAVERSE POINT(B)?:
```

```
TRAVERSE POINT #  2

ENTER TURNED ANGLE(CW): 270.0454

ENTER VERTICAL ANGLE  : 88.5141

ENTER SLOPE DISTANCE  : 160.162

BACKSITE AZIMUTH(DDD.MMSS)=    124.3951
    TURNED ANGLE(DDD.MMSS)=    270.0454
FORESITE AZIMUTH(DDD.MMSS)=     34.4445
  VERTICAL ANGLE(DDD.MMSS)=     88.5141

    HORIZ,VERT,SLOPE DIST =     160.130        3.183     160.162
CUM HORIZ,VERT,SLOPE DIST =     500.727        4.874     500.763

NRTH,EAST,ELEV THIS POINT = 1497698.720 9604059.859       -1.691
NRTH,EAST,ELEV NEXT POINT = 1497830.297 9604151.123        1.492

WOULD YOU LIKE TO PROCEED(P), REDO THIS TRAVERSE POINT(R),
OR BACKUP ONE TRAVERSE POINT(B)?:




TRAVERSE POINT #  3

ENTER TURNED ANGLE(CW): 261.5347

ENTER VERTICAL ANGLE  : 89.5637

ENTER SLOPE DISTANCE  : 211.307

BACKSITE AZIMUTH(DDD.MMSS)=    214.4445
    TURNED ANGLE(DDD.MMSS)=    261.5347
FORESITE AZIMUTH(DDD.MMSS)=    116.3832
  VERTICAL ANGLE(DDD.MMSS)=     89.5637

    HORIZ,VERT,SLOPE DIST =     211.307        0.208     211.307
CUM HORIZ,VERT,SLOPE DIST =     712.034        5.081     712.070

NRTH,EAST,ELEV THIS POINT = 1497830.297 9604151.123        1.492
NRTH,EAST,ELEV NEXT POINT = 1497735.543 9604339.995        1.700

WOULD YOU LIKE TO PROCEED(P), REDO THIS TRAVERSE POINT(R),
OR BACKUP ONE TRAVERSE POINT(B)?:
```

```
TRAVERSE POINT #  4

ENTER TURNED ANGLE(CW): 243.2310

ENTER VERTICAL ANGLE  : 90.2550

ENTER SLOPE DISTANCE  : 230.547


BACKSITE AZIMUTH(DDD.MMSS)=    296.3832
    TURNED ANGLE(DDD.MMSS)=    243.2310
FORESITE AZIMUTH(DDD.MMSS)=    180.0142
  VERTICAL ANGLE(DDD.MMSS)=     90.2550

    HORIZ.VERT,SLOPE DIST =     230.540      -1.732      230.547
CUM HORIZ,VERT,SLOPE DIST =     942.575       6.814      942.617

NRTH.EAST,ELEV THIS POINT = 1497735.543 9604339.995        1.700
NRTH.EAST,ELEV NEXT POINT = 1497505.003 9604339.981       -0.033

WOULD YOU LIKE TO PROCEED(P), REDO THIS TRAVERSE POINT(R),
OR BACKUP ONE TRAVERSE POINT(B)?:
```

CALCULATION SHEET - ERROR OF CLOSURE - RETRIEVER SOFTWARE

JOB: 26 Ma.

ORIGIN POINT NORTHING: 1497505.000

UNADJUSTED NORTHING : 1497505.003

NORTHING ERROR: .003

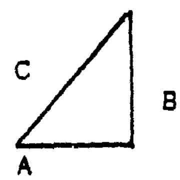
ORIGIN POINT EASTING : 9604430.000

UNADJUSTED EASTING : 9604339.881

EASTING ERROR: .019

DISTANCE: 942.575

A= .003
B= .019
C= .0192




ERROR OF CLOSURE: 1/ 49,092

This sheet is prepared because the current RETRIEVER softwar does not calculate the error of closure. The calculations must b done by hand based on next point N and E calculated by the program.

CALCULATION SHEET - ERROR OF CLOSURE - RETRIEVER SOFTWARE

JOB: 26 May 87

ORIGIN POINT NORTHING: 1107509.000

UNADJUSTED NORTHING : 1107508.986

NORTHING ERROR: .014

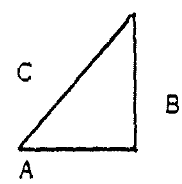
ORIGIN POINT EASTING : 9460360.000

UNADJUSTED EASTING : 9460360.009

EASTING ERROR: .009

DISTANCE: 1126.835

A= .014
B= .009
C= .01664




ERROR OF CLOSURE: 1/ 67,705

This sheet is prepared because the current RETRIEVER software does not calculate the error of closure. The calculations must be done by hand based on next point N and E calculated by the program.

## EVALUATION FIELD DATA

## APPENDIX J7

## SUN SHOT DATA

Sun shots were not taken inasmuch as the AISI instruments had already demonstrated a capability to perform star shots. The sun shot is at a much lower level (fourth order) than the star shot. Therefore, the question of the instruments being able to function properly is not in doubt. Consequently, if the instruments can perform star shots they will also perform sun shots.

EVALUATION FIELD DATA

APPENDIX J8

STAR SHOT DATA

The data, on star shots, (polaris), are provided to demonstrate that the instruments have the capability to perform astronomical observations. The data reduction program used was one that performs polaris and solar reduction without the use of an ephemeris. Observed data and data reduction outputs are as labeled. The exercise demonstrated the capability of the AISI instruments to function properly in a situation where "on board" lighting was a necessary requirement.

Polaris Observations Reduction For Job: "STAR SHOT"
(Using Hour Angle Method)

Date Of Observations (YYYY,MMDD): [illegible]

| Set No. | Az. Of Line From N. Deg | Min | Sec |
|---|---|---|---|
| 1 | [illegible] | 16 | 24 |
| [illegible] | 20 | 16 | 22 |
| [illegible] | 20 | 16 | 21 |
| 4 | [illegible] | 16 | 22 |
| 5 | 20 | 16 | [illegible] |
| 6 | 20 | 16 | 20 |
| [illegible] | 20 | 16 | 25 |
| 8 | 20 | 16 | 22 |
| 9 | 20 | 16 | 23 |
| 10 | 20 | 16 | 22 |
| 11 | 20 | 16 | [illegible] |
| 12 | 20 | 16 | 25 |
| 13 | 20 | 16 | 24 |

Mean Azimuth Of Line = 20 16 23.0
Standard Deviation Of The Mean = 0.5 Seconds

Polaris Observations Data For Job: "STAR SHOT"

Station Occupied Name: --------- OBSERVATORY
Back-Sight Station Name: ------ WATER TANK
Date Of Observations (YYYY.MMDD): 1997.0618
Latitude Of Station (DD.MMSSss): 38.445557
Longitude Of Station (DDD.MMSSss): -77.113224
Standard Longitude (HH.MM): --- -4.00

O B S E R V A T I O N S

| Set No. | Dir Rev. | Ref. Mark DDD.MMSSs | Star/Sun DDD.MMSSs | Time HH.MMSSs |
|---|---|---|---|---|
| 1 | Dir. | 0.00023 | 339.49178 | 21.57110 |
| 1 | Rev. | 180.00009 | 159.45370 | 21.56410 |
| 2 | Dir. | 0.00042 | 339.52038 | 22.10200 |
| 2 | Rev. | 180.00009 | 159.51222 | 22.08220 |
| 3 | Dir. | 0.00073 | 339.53373 | 22.15470 |
| 3 | Rev. | 180.00027 | 159.52526 | 22.14060 |
| 4 | Dir. | 0.00090 | 339.54550 | 22.20450 |
| 4 | Rev. | 179.59585 | 159.54162 | 22.19430 |
| 5 | Dir. | 0.00096 | 339.55599 | 22.25410 |
| 5 | Rev. | 180.00034 | 159.55346 | 22.24220 |
| 6 | Dir. | 0.00029 | 339.57103 | 22.30000 |
| 6 | Rev. | 179.59591 | 159.56453 | 22.28550 |
| 7 | Dir. | 0.00023 | 339.58491 | 22.36360 |
| 7 | Rev. | 180.00013 | 159.58098 | 22.34380 |
| 8 | Dir. | 359.59574 | 340.00148 | 22.42150 |
| 8 | Rev. | 180.00015 | 159.59371 | 22.40110 |
| 9 | Dir. | 0.00024 | 340.01158 | 22.46060 |
| 9 | Rev. | 180.00018 | 160.00507 | 22.44590 |
| 10 | Dir. | 0.00009 | 340.02089 | 22.49370 |
| 10 | Rev. | 180.00004 | 160.01463 | 22.48390 |
| 11 | Dir. | 0.00043 | 340.03149 | 22.53440 |
| 11 | Rev. | 180.00012 | 160.02412 | 22.52140 |
| 12 | Dir. | 0.00042 | 340.04285 | 22.58500 |
| 12 | Rev. | 180.00003 | 160.04022 | 22.57550 |
| 13 | Dir. | 0.00037 | 340.08178 | 23.13500 |
| 13 | Rev. | 179.59589 | 160.07242 | 23.12050 |



(End Of Data)

Polaris Observations Reduction For Job: "GEODIMETER TEST"
(Using Hour Angle Method)

Date Of Observations (YYYY.MMDD): 1987.0625

| Set NO | Az. Of Line From N. Deg | Min | Sec |
|---|---|---|---|
| 1 | 20 | 16 | 27 |
| 2 | 20 | 16 | 32 |
| 3 | 20 | 16 | 30 |
| 4 | 20 | 16 | 27 |
| 5 | 20 | 16 | 28 |
| 6 | 20 | 16 | 24 |
| 7 | 20 | 16 | 25 |
| 8 | 20 | 16 | 28 |
| 9 | 20 | 16 | 30 |
| 10 | 20 | 16 | 28 |
| 11 | 20 | 16 | 26 |
| 12 | 20 | 16 | 24 |

Mean Azimuth Of Line = 20 16 27.2
Standard Deviation Of The Mean = 0.7 Seconds

Polaris Observations Data For Job: "GEODIMETER TEST"

Station Occupied Name: -------> OBSERVATOR
BackSight Station Name: ------> WATER TANK
Date Of Observations (YYYY.MMDD): 1987.0625
Latitude Of Station (DD.MMSSss): 38.445993
Longitude Of Station (DDD.MMSSss): -77.113324
Standard longitude (HH.MM): ---> -4.00

O B S E R V A T I O N S

| Set No. | Cir Pos | Ref. Mark DDD.MMSSs | Star/Sun DDD.MMSSs | Time HH.MMSSs |
|---|---|---|---|---|
| 1 | Dir. | 0.00000 | 339.51060 | 21.41420 |
| 1 | Rev. | 179.59400 | 159.51100 | 21.40060 |
| 2 | Dir. | 0.00000 | 339.53280 | 21.47100 |
| 2 | Rev. | 179.59440 | 159.523[illegible] | 21.45430 |
| 3 | Dir. | 0.00020 | 339.54380 | 21.55180 |
| 3 | Rev. | 179.59420 | 159.54540 | 21.54210 |
| 4 | Dir. | 0.00000 | 339.56080 | 22.00590 |
| 4 | Rev. | 179.59400 | 159.56000 | 21.58310 |
| 5 | Dir. | 359.59560 | 339.59300 | 22.14300 |
| 5 | Rev. | 179.59350 | 159.59480 | 22.13140 |
| 6 | Dir. | 359.59560 | 340.00400 | 22.18470 |
| 6 | Rev. | 179.59380 | 160.00580 | 22.17430 |
| 7 | Dir. | 359.59560 | 340.01320 | 22.22130 |
| 7 | Rev. | 179.59380 | 160.01520 | 22.21290 |
| 8 | Dir. | 359.59580 | 340.02360 | 22.26250 |
| 8 | Rev. | 179.59380 | 160.02420 | 22.24590 |
| 9 | Dir. | 359.59560 | 340.03240 | 22.30070 |
| 9 | Rev. | 179.59380 | 160.03420 | 22.285[illegible] |
| 10 | Dir. | 359.59560 | 340.04200 | 22.33410 |
| 10 | Rev. | 179.59720 | 160.04340 | 22.32130 |
| 11 | Dir. | 359.59480 | 340.07200 | 22.46190 |
| 11 | Rev. | 179.59700 | 160.07400 | 22.45070 |
| 12 | Dir. | 359.59400 | 340.08120 | 22.49440 |
| 12 | Rev. | 179.59[illegible] | 160.08200 | 22.45[illegible] |



(End Of Data)

Polaris Observations Reduction For Job: "STAR SHOT"
(Using Hour Angle Method)

Date Of Observations (YYYY.MMDD): 1987.0618

| Set NO | Az. Of Line From N. Deg | Min | Sec |
| --- | --- | --- | --- |
| 1 | 20 | 16 | 14 |
| 2 | 20 | 16 | 24 |
| 3 | 20 | 16 | 16 |
| 4 | 20 | 16 | 22 |
| 5 | 20 | 16 | 21 |
| 6 | 20 | 16 | 22 |
| 7 | 20 | 16 | 26 |
| 8 | 20 | 16 | 20 |
| 9 | 20 | 16 | 25 |
| 10 | 20 | 16 | 22 |
| 11 | 20 | 16 | 23 |
| 12 | 20 | 16 | 22 |
| 13 | 20 | 16 | 22 |
| 14 | 20 | 16 | 25 |
| 15 | 20 | 16 | 1 |
| 16 | 20 | 16 | 24 |

Mean Azimuth Of Line = 20 16 20.6
Standard Deviation Of The Mean = 1.5 Seconds

## EVALUATION FIELD DATA

## APPENDIX J9

## MAXIMUM RANGE DATA

Maximum range data are included to provide verification for the claim by the manufacturers that their instrument will measure a distance of seven kilometers to a specified number of prisms under excellent atmospheric conditions. In addition it also provides information to answer the issue of maximum distance capability stated in the requirements documents. As noted in the data provided only one instrument met the requirement when the initial distance exercise was conducted. It was subsequently determined that the failed instrument contained defective components that the manufacturer had purchased as being certified for higher level of performance. Corrective action was taken in relation to all instruments that contained defective components. The data collected during the second exercise show that the standard instrument was capable of meeting the maximum distance requirement.

# AISI MAXIMUM RANGE TRIAL

Date - 7/16/87 Pressure - 745.0 Temp - 78.0F PPM = 1
Time - 12:20 PM

Wild T-2000 & DI55

11 Prisms

| | HD | Residual $\nu$ | $\nu^2$ |
|---|---|---|---|
| 1. | 7094.345 | .000 | |
| 2. | 7094.347 | +.002 | .000004 |
| 3. | 7094.347 | +.002 | .000004 |
| 4. | 7094.345 | .000 | |
| 5. | 7094.349 | +.004 | .000016 |
| 6. | 7094.343 | -.002 | .000004 |
| 7. | 7094.347 | +.002 | .000004 |
| 8. | 7094.342 | -.003 | .000009 |
| 9. | 7094.343 | -.002 | .000004 |
| 10. | 7094.346 | +.001 | .000001 |
| | 70943.454 | +.004 | .000046 |

= 7094.3454

$$\sigma = \pm\sqrt{\frac{\sum \nu^2}{n-1}}$$

$$\sigma = \pm\sqrt{\frac{.000046}{9}}$$

$$\sigma = \pm .00226$$

## AISI MAXIMUM RANGE TRIAL

Date - 7/16/87 Pressure - 745.0 Temp - 78.0F PPM = 1
Time - 6:13 PM

Geodimeter 440 12 Prisms

Would not measure.

16 Prisms

| | HD | Residual $\nu^2$ | $\nu^2$ |
|---|---|---|---|
| 1. | 7094.58 | +.01 | .0001 |
| 2. | 7094.57 | .00 | |
| 3. | 7094.57 | .00 | |
| 4. | 7094.56 | -.01 | .0001 |
| 5. | 7094.59 | +.02 | .0004 |
| 6. | 7094.58 | +.01 | .0001 |
| 7. | 7094.56 | -.01 | .0001 |
| 8. | 7094.58 | +.01 | .0001 |
| 9. | 7094.58 | +.01 | .0001 |
| 10. | 7094.54 | -.03 | .0009 |
| | 70945.71 | -.01 | .0019 |
| | = 7094.57 | $\sigma = \pm\sqrt{\frac{\sum \nu^2}{n-1}}$ | $\sigma = \pm\sqrt{\frac{.0019}{9}}$ |
| | | | $\sigma = \pm.01453$ |

Instrument found to have defective components.

AISI MAXIMUM RANGE TRIAL (Supplemental)

Date - 2/25/88     Pressure - 29.8" Hq     Temperature - 30 Degrees F
Time - 10:50 AM

Trial conducted with instrument containing replacements for defective components.

Geodimeter 440     8 Prisms

| | SD | HD(Cal) |
|---|---|---|
| 1. | 7099.644 | |
| 2. | 7099.362 | |
| 3. | 7099.636 | |
| 4. | 7099.640 | |
| 5. | 7099.636 | |
| 6. | 7099.644 | |
| 7. | 7099.634 | |
| 8. | 7099.633 | |
| 9. | 7099.633 | |
| 10. | 7099.657 | |

| | HD |
|---|---|
| 1. | 7094.348 |
| 2. | 7094.385 |
| 3. | 7094.363 |

# EVALUATION FIELD DATA

## APPENDIX J10

## MISCELLANEOUS DATA

The data shown in this appendix are provided for verification of certain technical characteristics and for general information on selected instrument components and capabilities. The various elements of miscellaneous data are as labeled. Such items as data on "time to measure" are used to determine if the instrument performance is satisfactory in comparison to the requirements documents.

# MISCELLANEOUS DATA

WILD T2000 #M2246

3/30/87

Stadia Constant 1 = 1.00 @ 100 ft.

**Field of View**

| | | | |
|---|---|---|---|
| 107 | 13 | 26.3 | |
| 108 | 46 | 30.2 | |
| | | | |
| 01 | 33 | 03.9 | |

**Dbl. Ret.**

| | | | |
|---|---|---|---|
| 107 | 59 | 42.2 | |
| 108 | 00 | 16.9 | 34.7 |
| | | | |
| 107 | 59 | 42.9 | |
| 108 | 00 | 18.4 | 35.5 |

**Line Weight**

| | | | |
|---|---|---|---|
| 107 | 59 | 55.6 | |
| 107 | 59 | 58.3 | 2.7 |
| | | | |
| 107 | 59 | 56.4 | |
| 108 | 00 | 00.1 | 3.7 |

GEODIMETER #69147

Stadii Constant Top/Bottom 1:100

GEODIMETER DATA

**Field of View**

| | | | |
|---|---|---|---|
| 107 | 15 | 00 | |
| 108 | 45 | 00 | |
| | | | |
| 01 | 30 | 00 | |

**Dbl. Ret.**

| | | | |
|---|---|---|---|
| 108 | 00 | 14 | |
| 107 | 59 | 72 | 46 |
| | | | |
| 108 | 00 | 14 | |
| 107 | 59 | 36 | 50 |

**Line Weight**

| | | | |
|---|---|---|---|
| 107 | 59 | 55 | |
| 108 | 00 | 00 | 05 |
| | | | |
| 107 | 59 | 56 | |
| 107 | 59 | 58 | 02 |
| | | | |
| 108 | 00 | 01 | |
| 108 | 00 | 04 | 03 |

## AISI MEASUREMENT TIME FIGURES

To determine the measurement time two targets were set up and the instruments set up and leveled. A series of angle and distance shots were made to determine the time elapsed from the pushing of the button that initiated the measurement until the results were displayed for the operator. It was found that over the distances of interest no appreciable difference in time resulted at varying distances. The following results were obtained from the trials run:

GEODIMETER: Time for single measurement-- 6.0 sec.

Time for single measurement in continuous mode-- 1.0 sec.

WILD: Time for single measurement-- 5.5 sec.

Time for single measurement in continuous mode-- 1.0 sec.

## EVALUATION FIELD DATA

## APPENDIX J11

## MANUAL INPUT DATA

Data showing the manual (through keyboard) input format and its raw data structure are included to verify the fact that manual input of data is possible. This capability is a requirement that was verified. With this capability the transfer of data in the data collector or the instrument, that cannot be moved electronically, can be transferred even though it is somewhat slow and awkward. The raw data format presents a distinctive appearance. However, once moved to the edit file it is not readily distinguishable from data entered via a data collector.

MANUAL INPUT DATA RAW DATA

| |
|---|
| 2.0000 |
| -1.0000 |
| 1.0000 |
| 1.0000 |
| 31987.0000 |
| -2.0000 |
| 20.0000 |
| 0.0000 |
| 0.0000 |
| 3.0000 |
| 74.5708 |
| 88.4450 |
| 67.2400 |
| -4.0000 |
| 500.0000 |
| 0.0000 |
| 0.0000 |
| 5.0000 |
| 85.4144 |
| 88.5742 |
| 54.6400 |
| -6.0000 |
| 500.0000 |
| 0.0000 |
| 0.0000 |
| 7.0000 |
| 135.5750 |
| 91.0141 |
| 40.3700 |
| -8.0000 |
| 40.0000 |
| 10.0000 |
| 10.0000 |
| -9.0000 |
| 40.0000 |
| 0.0000 |
| 0.0000 |
| -10.0000 |
| 500.0000 |
| 0.0000 |
| 0.0000 |
| 11.0000 |
| 153.1900 |
| 88.0742 |
| 45.3100 |
| -12.0000 |
| 510.0000 |
| 0.0000 |
| 0.0000 |
| 13.0000 |
| 159.4236 |
| 87.5438 |
| 48.8200 |
| -14.0000 |
| 383.0000 |
| 1.0000 |
| 0.0000 |
| 15.0000 |
| 177.3738 |
| 89.4110 |
| 63.8800 |

# EDITED DATA

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| A0001P | P | 1 | 001 001 | 1 | 31987 | 00-00 | 1 | 31987 |
| -0002P | P | 1 | 020 020 | 0 | 0 | 00-00 | 0 | 0 |
| -0002F | P010000000 | 1 | 021 021 | 1000000 | 1000000 | 00 00 | 1000000 | 1000000 |
| -0003 | P | 1 | 745708 | 884450 | 67240 | 67223 | 1470 | 745708 |
| -0004P | P | 1 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0005 | P | 2 | 854144 | 885742 | 54640 | 54631 | 990 | 854144 |
| -0006P | P | 2 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0007 | P | 3 | 1355750 | 910141 | 40370 | 40363 | -724 | 1355750 |
| -0008P | PXX | 3 | 040 040 | 10 | 10 | 00-00 | 10 | 10 |
| -0009P | PXX | 3 | 040 040 | 0 | 0 | 00-00 | 0 | 0 |
| -0010P | P | 3 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0011 | P | 4 | 1531900 | 880742 | 45310 | 45285 | 1479 | 1531900 |
| -0012P | P | 4 | 510 510 | 0 | 0 | 00-00 | 0 | 0 |
| -0013 | P | 5 | 1594236 | 875438 | 48820 | 48787 | 1779 | 1594236 |
| -0014P | P | 5 | 383 383 | 1 | 0 | 00-00 | 1 | 0 |
| -0015 | P | 6 | 1773738 | 894110 | 63880 | 63879 | 349 | 1773738 |
| -0016P | P | 6 | 383 383 | 1 | 0 | 00-00 | 1 | 0 |
| -0017 | P | 7 | 1814204 | 894123 | 70200 | 70198 | 380 | 1814204 |
| -0018P | P | 7 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0019 | P | 8 | 1875530 | 0921459 | 84580 | 11771 | -0003320 | 1875530 |
| -0020P | P | 8 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0021 | P | 9 | 1665138 | 914630 | 119780 | 119722 | -3710 | 1665138 |
| -0022P | P | 9 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0023 | P | 10 | 1590156 | 894842 | 106410 | 106409 | 349 | 1590156 |
| -0024P | P | 10 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0025 | P | 11 | 1560754 | 894645 | 103840 | 103839 | 400 | 1560754 |
| -0026P | P | 11 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0027 | P | 12 | 1434720 | 894650 | 96560 | 96559 | 369 | 1434720 |
| -0028P | P | 12 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0029 | P | 13 | 1380056 | 893206 | 94870 | 94866 | 769 | 1380056 |
| -0030P | P | 13 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0031 | P | 14 | 1312144 | 903148 | 94060 | 94055 | -870 | 1312144 |
| -0032P | P | 14 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0033 | P | 15 | 1022954 | 891414 | 108150 | 108140 | 1439 | 1022954 |
| -0034P | P | 15 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0035 | P | 16 | 883036 | 892447 | 128890 | 128883 | 1320 | 883036 |
| -0036P | P | 16 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0037 | P | 17 | 981118 | 893019 | 176070 | 176063 | 1520 | 981118 |
| -0038P | P | 17 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0039 | P | 18 | 1111412 | 892850 | 162130 | 162123 | 1469 | 1111412 |
| -0040P | P | 18 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0041 | P | 19 | 1314150 | 902836 | 157510 | 157504 | -1310 | 1314150 |
| -0042P | P | 19 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0043 | P | 20 | 1390330 | 893733 | 160800 | 160796 | 1050 | 1390330 |
| -0044P | P | 20 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0045 | PXX | 21 | 1390330 | 893733 | 160800 | 160796 | 1050 | 1390330 |
| -0046P | PXX | 21 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0047 | P | 22 | 1464654 | 894657 | 165990 | 165988 | 630 | 1464654 |
| -0048P | P | 22 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0049 | P | 23 | 1514158 | 901706 | 170820 | 170817 | -849 | 1514158 |
| -0050P | P | 23 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0051 | P | 24 | 1533703 | 910156 | 172630 | 172601 | -3109 | 1533703 |
| -0052P | P | 24 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0053 | P | 25 | 1354526 | 0895359 | 159770 | 0159770 | 0000280 | 1354526 |
| -0054P | P | 25 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0055 | P | 26 | 1535308 | 911723 | 154600 | 154560 | -3479 | 1535308 |
| -0056P | P | 26 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0057 | P | 27 | 1491836 | 903627 | 215060 | 215047 | -2280 | 1491836 |
| -0058P | P | 27 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0059 | P | 28 | 1463748 | 895305 | 213910 | 213909 | 430 | 1463748 |
| -0060P | P | 28 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0060 | P010000029 | | 1400150 | [illegible] | [illegible] | [illegible] | | |

## EVALUATION FIELD DATA

## APPENDIX J12

## TOPOGRAPHIC DATA

Data collected during the conduct of topographic exercises have been processed and included to verify that the instruments and associated support equipment do perform the functions necessary in topographic surveying. The data are shown in the various file formats used during the processing. The data are shown initially in their raw state (as collected in the field) then in their edited format, and then in the format necessary for interface with the computer aided design programs that produce the plots or other outputs used in the topographic field. Included as examples are two very basic output products of the computer aided design programs. Each demonstrates that the complete procedure from the collection of data in the field to the output of a finished product is possible with the system evaluated. It must be noted that the quality of the output is not what should be expected from trained personnel using properly interfaced system components. The inference that it is difficult to interface the components should not be drawn but rather that time was not taken to set up all the parameters and conditions to produce the quality product that would be required when the system is placed in full operation. Also the personnel using the equipment were not trained specifically in that area but rather had expertise in the use of computers and computer aided design programs in a variety of applications.

TOPOGRAPHIC DATA

RAW DATA

2000

0,50=2

1.81=1

2.82=2

3,83=300687

4,81=20

5,82=0

6,83=0

7,81=21

8,82=5000000

9.83=5000000

0,7=0

1.8=89.5954

2,9=275.05

3,81=40

4,82=1

5.83=2

6.7=74.5722

7,8=88.3038

8,9=67.25

9,81=500

0,82=1

1,83=101

2,7=85.4256

3.8=88.3956

4,9=54.65

5,81=500

6,82=1

7,83=102

8,7=153.1854

9,8=87.4708

2,32=0

3,83=0

4,7=159.4318

5,8=87.3508

6,9=48.77

7,81=500

8,82=0

9,83=0

0,7=177.3642

1,8=89.263

2,9=63.94

3,81=500

4,82=0

5,83=0

6,7=181.4334

7,8=89.3908

8,9=70.15

9,81=500

0,82=0

1,83=0

2,7=187.5912

3,8=92.045

4,9=84.58

5,81=500

6,82=0

7,83=0

8,7=166.1856

9,8=91.3826

0,9=119.45

1,81=500

2,82=0

4,7=159.Ø252

5,8=89.37Ø6

6,9=1Ø6.35

7,81=5ØØ

8,82=Ø

9,83=Ø

Ø,7=156.Ø928

1,8=89.3712

2,9=1Ø3.88

3,81=5ØØ

4,82=Ø

5.83=Ø

6,7=143.4842

7,8=88.58Ø8

8,9=96.57

9,81=5ØØ

Ø,82=Ø

1,83=Ø

2,7=139.Ø138

3,8=89.2132

4,9=94.96

5,81=5ØØ

6,82=Ø

7,83=Ø

8,7=131.2228

9,8=9Ø.2118

Ø,9=94.13

1,81=5ØØ

2,82=Ø

3,83=Ø

4,7=1Ø2.3246

5,8=89.Ø532

7,81=5ØØ

8,82=Ø

9,83=Ø

Ø,7=88.3Ø24

1,8=89.1746

2,9=129.91

3,81=5ØØ

4,82=Ø

5,83=Ø

6,7=98.1212

7,8=89.2512

8,9=176.Ø7

9,81=5ØØ

Ø,82=Ø

1,83=Ø

2,7=111.1254

3,8=89.222

4,9=162.12

5,81=5ØØ

6,82=Ø

7,83=Ø

8,7=131.425

9,8=9Ø.23

Ø,9=157.53

1,81=5ØØ

2,82=Ø

3,83=Ø

4,7=139.Ø359

5,8=89.3Ø56

6,9=16Ø.83

7,81=5ØØ

8,82=Ø

1,8=89.4Ø54

2,9=165.9

3,81=5ØØ

4,82=Ø

5,83=Ø

6,7=151.4146

7,8=9Ø.1Ø5

8,9=17Ø.79

9,81=5ØØ

Ø,82=Ø

1,83=Ø

2,7=153.3528

3,8=9Ø.582

4,9=172.23

5,81=5ØØ

6,82=Ø

7,83=Ø

8,7=153.5826

9,8=91.1Ø56

Ø,9=318446.73

1,81=5ØØ

2,82=Ø

3,83=Ø

4,7=149.1436

5,8=9Ø.3118

6,9=214.63

7,81=5ØØ

8,82=Ø

9,83=Ø

Ø,7=146.374

1,8=89.475

4.82=0

5.83=0

6.7=144.0134

7,8=89.4346

8,9=211.97

9.81=500

0,82=0

1.83=0

2,7=138.0236

3,8=89.4014

4.9=208.82

5.81=500

6,82=0

7,83=0

8,7=135.3838

9,8=89.4656

0,9=208.29

1,81=500

2,82=0

3,83=0

4,7=132.2328

5.8=90.2934

6,9=207.95

7,81=500

8,82=0

9,83=0

0.7=133.4754

1.8=90.3906

2,9=201.94

3.81=500

4,82=0

6,7=114,3944

7,8=89.313

8,9=220.25

9,81=500

0.82=0

1,83=0

2.7=104.5816

3,8=89.3318

4,9=237.37

5,81=500

6,82=0

7.83=0

8,7=94.5918

9,8=89.3418

0,9=264.41

1,81=500

2,82=0

3.83=0

4,7=100.002

5.8=89.383

6,9=311.09

7.81=500

8,82=0

9,83=0

0,7=108.3738

1,8=89.3716

2,9=291.53

3,81=500

4,82=0

5,83=0



6,7=121.0104

7,8=89.4812

0,83=0

1,83=0

2,7=121.5342

3,8=89.491

4,9=256.1

5,81=500

6,82=0

7,83=0

8,7=132.0902

9,8=90.19

0,9=260.62

1,81=500

2,82=0

3,83=0

4,7=135.1834

5,8=89.5044

6,9=286.23

7,81=500

8,82=0

9,83=0

0,7=137.1826

1,8=89.4456

2,9=286.35

3,81=500

4,82=0

5,83=0

6,7=141.4232

7,8=89.4438

8,9=286.95

9,81=500

0,82=0

2,7=143.142

3,8=89.491

4,9=291.21

5,81=5ØØ

6,82=Ø

7,83=Ø

8,7=145.Ø926

9,8=9Ø.1554

Ø,9=288.13

1,81=5ØØ

2,82=Ø

3,83=Ø

4,7=143.134

5,8=9Ø.Ø646

6,9=342.93

7,81=5ØØ

8,82=Ø

9,83=Ø

Ø,7=142.Ø748

1,8=89.4844

2,9=341.86

3,81=5ØØ

4,82=Ø

5,83=Ø

6,7=14Ø.4332

7,8=89.4612

8,9=339.74

9,81=5ØØ

Ø,82=Ø

1,83=Ø

2,7=137.ØØ1

3,8=89.4532

[illegible]

5,81=500

6,82=0

7,83=0

8,7=135.2126

9,8=89.4958

0,9=337.69

1,81=500

2,82=0

3,83=0

4,7=132.4722

5,8=90.1454

6,9=341.38

7,81=500

8,82=0

9,83=0

0,7=121.2258

1,8=89.5244

2,9=338.98

3,81=500

4,82=0

5,83=0

6,7=119.0734

7,8=89.414

8,9=341.47

9,81=500

0,82=0

1,83=0

2,7=111.0936

3,8=89.405

4,9=347.05

5,81=500

6,82=0

7,83=0

8,7=1Ø3.5132

9,8=89.4236

Ø,9=359.69

1,81=5ØØ

2,82=Ø

3,83=Ø

4,7=88.5ØØ6

5,8=89.241

6,9=194.Ø4

7,81=5ØØ

8,82=Ø

9,83=Ø

Ø,7=78.2Ø44

1,8=89.16Ø2

2,9=154.84

3,81=5ØØ

4,82=Ø

5,83=Ø

6,7=135.47Ø6

7,8=89.4722

8,9=159.68

9,81=5ØØ

Ø,82=Ø

1,83=Ø

2,7=229.49Ø6

3,8=9Ø.223

4,9=18Ø.81

5,81=41

6,82=1

7,83=3

8,81=2Ø

9,82=3

2,8=89.2222

3,9=180.83

4,81=40

5,82=3

6,83=1

7,7=38.5524

8,8=89.4452

9,9=104.66

0,81=500

1,82=0

2,83=0

3,7=42.4058

4,8=89.3014

5,9=99.71

6,81=500

7,82=0

8,83=0

9,7=53.1046

0,8=89.335

1,9=89.99

2,81=500

3,82=0

4,83=0

5,7=57.531

6,8=90.2216

7,9=86.84

8,81=500

9,82=0

0,83=0

1,7=65.2212



2,8=92.5358

4,81=5ØØ

5,82=Ø

6,83=Ø

7,7=6Ø.1946

8,8=93.Ø946

9,9=95.6

Ø,81=5ØØ

1,82=Ø

2,83=Ø

3,7=78.18Ø4

4,8=87.4946

5,9=81.82

6,81=5ØØ

7,82=Ø

8,83=Ø

9,7=9Ø.534

Ø,8=9Ø.5346

1,9=84.72

2,81=5ØØ

3,82=Ø

4,83=Ø

5,7=1Ø8.3ØØ8

6,8=9Ø.5244

7,9=12Ø.56

8,81=5ØØ

9,82=Ø

Ø,83=Ø

1,7=133.3626

2,8=9Ø.514

3,9=99.7

4,81=5ØØ

```
7,7=161.271
8,8=89.5218
9,9=99.17
Ø,81=5ØØ
1,82=Ø
2,83=Ø
3,7=153.3146
4,8=89.5444
5,9=148.45
6,81=5ØØ
7,82=Ø
8,83=Ø
9,7=134.4812
Ø,8=9Ø.4334
1,9=148.6
2,81=5ØØ
3,82=Ø
4,83=Ø
5,7=117.3Ø46
6,8=9Ø.5738
7,9=164.91
8,81=5ØØ
9,82=Ø
Ø,83=Ø
1,7=111.5612
2,8=92.Ø254
3,9=178.34
4,81=5ØØ
5,82=Ø
6,83=Ø
7,7=1Ø7.14Ø4
8,8=9Ø.4Ø52
```

```
Ø,81=5ØØ
1,82=Ø
2,83=Ø
3,7=95.3834
4,8=9Ø.3952
5,9=16Ø.11
6.81=5ØØ
7,82=Ø
8,83=Ø
9,7=1Ø2.Ø748
Ø,8=93.15
1,9=139.91
2,81=5ØØ
3,82=Ø
4,83=Ø
5,7=9Ø.Ø924
6,8=92.4Ø12
7,9=112.37
8,81=5ØØ
9,82=Ø
Ø,83=Ø
1,7=78.2318
2,8=9Ø.291
3,9=134.63
4,81=5ØØ
5,82=Ø
6,83=Ø
7,7=78.Ø636
8,8=89.5836
9,9=194
Ø,81=5ØØ
1,82=Ø
```

3,7=69.5232

4,8=89.4334

5,9=240.06

6,81=5ØØ

7,82=Ø

8,83=Ø

9,7=69.5232

Ø,8=89.4216

1,9=295.69

2,81=5ØØ

3,82=Ø

4,83=Ø

5,7=7Ø.1752

6,8=89.4342

7,9=37Ø.92

8,81=5ØØ

9,82=Ø

Ø,83=Ø

1,7=62.Ø44

2,8=89.435

3,9=2ØØ.74

4,81=5ØØ

5,82=Ø

6,83=Ø

7,7=61.Ø436

8,8=89.394

9,9=157.51

Ø,81=5ØØ

1,82=Ø

2,83=Ø

3,7=42.4828

4,8=91.4614

```
6,B1=500
7,B2=0
8,B3=0
```

EDITED DATA

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| A0001P | P | 1 | 001 001 | 2 | 300687 | 00-00 | 2 | 300687 |
| -0002P | P | 1 | 020 020 | 0 | 0 | 00-00 | 0 | 0 |
| -0003P | P | 1 | 021 021 | 5000000 | 5000000 | 00-00 | 5000000 | 5000000 |
| -0004 | P | 1 | 0 | 895954 | 275050 | 275050 | 8 | 0 |
| -0005P | P | 2 | 040 040 | 1 | 2 | 00-00 | 1 | 2 |
| -0006 | P | 2 | 745722 | 983038 | 67250 | 67227 | 1748 | 745722 |
| -0007P | P | 3 | 500 500 | 1 | 101 | 00-00 | 1 | 101 |
| -0008 | P | 3 | 854256 | 983956 | 54650 | 54635 | 1272 | 854256 |
| -0009P | P | 4 | 500 500 | 1 | 102 | 00-00 | 1 | 102 |
| -0010 | P | 4 | 1531854 | 874708 | 45310 | 45276 | 1750 | 1531854 |
| -0011P | P | 5 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0012 | P | 5 | 1594318 | 873508 | 48770 | 48726 | 2054 | 1594318 |
| -0013P | P | 6 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0014 | P | 6 | 1773642 | 892630 | 63940 | 63936 | 623 | 1773642 |
| -0015P | P | 7 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0016 | P | 7 | 1814334 | 893908 | 70150 | 70142 | 425 | 1814334 |
| -0017P | P | 8 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0018 | P | 8 | 1875912 | 920450 | 84580 | 84524 | -3070 | 1875912 |
| -0019P | P | 9 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0020 | P | 9 | 1661856 | 913826 | 119450 | 119401 | -3419 | 1661856 |
| -0021P | P | 10 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0022 | P | 10 | 1590252 | 893906 | 106350 | 106348 | 646 | 1590252 |
| -0023P | P | 11 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0024 | P | 11 | 1560928 | 893712 | 103880 | 103877 | 688 | 1560928 |
| -0025P | P | 12 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0026 | P | 12 | 1434842 | 885808 | 96570 | 96554 | 1737 | 1434842 |
| -0027P | P | 13 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0028 | P | 13 | 1380138 | 892132 | 94960 | 94954 | 1062 | 1380138 |
| -0029P | P | 14 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0030 | P | 14 | 1312228 | 902118 | 94130 | 94128 | -583 | 1312228 |
| -0031P | P | 15 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0032 | P | 15 | 1023246 | 890532 | 108120 | 108106 | 1712 | 1023246 |
| -0033P | P | 16 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0034 | P | 16 | 883024 | 891746 | 128910 | 128900 | 1583 | 883024 |
| -0035P | P | 17 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0036 | P | 17 | 981212 | 892512 | 176070 | 176060 | 1782 | 981212 |
| -0037P | P | 18 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0038 | P | 19 | 1111254 | 892220 | 162120 | 162110 | 1776 | 1111254 |
| -0039P | F | 19 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0040 | P | 19 | 1314250 | 902300 | 157530 | 157526 | -1053 | 1314250 |
| -0041P | F | 20 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0042 | P | 20 | 1390358 | 893056 | 160830 | 160824 | 1359 | 1390358 |
| -0043P | F | 21 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0044 | P | 21 | 1464752 | 894054 | 165900 | 165897 | 921 | 1464752 |
| -0045P | F | 22 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0046 | P | 22 | 1514146 | 901050 | 170790 | 170789 | -538 | 1514146 |
| -0047P | F | 23 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0048 | P | 23 | 1533528 | 905820 | 172230 | 172205 | -2922 | 1533528 |
| -0049P | F | 24 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0050 | P | 24 | 1535826 | 911056 | ******* | ******* | -380596 | 1535826 |
| -0051P | P | 25 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0052 | P | 25 | 1491436 | 903118 | 214630 | 214621 | -1954 | 1491436 |
| -0053P | P | 26 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0054 | P | 26 | 1463740 | 894750 | 213850 | 213848 | 756 | 1463740 |
| -0055P | F | 27 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0056 | P | 27 | 1440134 | 894346 | 211970 | 211967 | 1000 | 1440134 |
| -0057P | P | 28 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0058 | P | 29 | 1380236 | 894014 | 208820 | 208816 | 1200 | 1380236 |
| -0059P | F | 29 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0060 | P | 29 | 1353838 | 894656 | 208290 | 208288 | 791 | 1353838 |
| -0061P | P | 30 | 500 500 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| -ØØ63P | P | 31 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | | |
| -ØØ64 | P | 31 | 1334754 | 9Ø39Ø6 | 2Ø194Ø | 2Ø1926 | Ø | Ø |
| -ØØ65P | P | 32 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | -2296 | 1334754 |
| -ØØ66 | P | 32 | 1143944 | 89313Ø | 22Ø25Ø | 22Ø242 | Ø | Ø |
| -ØØ67P | P | 33 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 1825 | 1143944 |
| -ØØ68 | P | 33 | 1Ø45816 | 893319 | 23737Ø | 237362 | Ø | Ø |
| -ØØ69P | P | 34 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 1943 | 1Ø45816 |
| -ØØ7Ø | P | 34 | 945918 | 893418 | 26441Ø | 2644Ø2 | Ø | Ø |
| -ØØ71P | P | 35 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 1976 | 945918 |
| -ØØ72 | P | 35 | 1ØØØØ2Ø | 89383Ø | 311Ø9Ø | 311Ø93 | Ø | Ø |
| -ØØ73P | P | 36 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 1945 | 1ØØØØ2Ø |
| -ØØ74 | P | 36 | 1Ø83738 | 893716 | 29153Ø | 291523 | Ø | Ø |
| -ØØ75P | P | 37 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 1927 | 1Ø93738 |
| -ØØ76 | P | 37 | 121Ø1Ø4 | 894812 | 2731ØØ | 273Ø98 | Ø | Ø |
| -ØØ77P | P | 38 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 937 | 121Ø1Ø4 |
| -ØØ78 | P | 38 | 1215342 | 89491Ø | 2561ØØ | 256Ø98 | Ø | Ø |
| -ØØ79P | P | 39 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 8Ø7 | 1215342 |
| -ØØ8Ø | P | 39 | 1351834 | 895Ø44 | 28623Ø | 286228 | Ø | Ø |
| -ØØ81P | P | 4Ø | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 771 | 1351834 |
| -ØØ82 | P | 4Ø | 1371826 | 894456 | 28635Ø | 296347 | Ø | Ø |
| -ØØ83P | P | 41 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 1254 | 1371826 |
| -ØØ84 | P | 41 | 1414232 | 894439 | 28695Ø | 286947 | Ø | Ø |
| -ØØ85P | P | 42 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 1282 | 1414232 |
| -ØØ86 | P | 42 | 143142Ø | 89491Ø | 29121Ø | 2912Ø9 | Ø | Ø |
| -ØØ87P | P | 43 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 917 | 143142Ø |
| -ØØ88 | P | 43 | 145Ø926 | 9Ø1554 | 28813Ø | 288126 | Ø | Ø |
| -ØØ89P | P | 44 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | -1332 | 145Ø926 |
| -ØØ9Ø | P | 44 | 143134Ø | 9ØØ646 | 34293Ø | 342929 | Ø | Ø |
| -ØØ91P | P | 45 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | -675 | 143134Ø |
| -ØØ92 | P | 45 | 142Ø748 | 894844 | 34186Ø | 341858 | Ø | Ø |
| -ØØ93P | P | 46 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 112Ø | 142Ø748 |
| -ØØ94 | P | 46 | 14Ø4332 | 894612 | 33974Ø | 339737 | Ø | Ø |
| -ØØ95P | P | 47 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 1363 | 14Ø4332 |
| -ØØ96 | P | 47 | 137ØØ1Ø | 894532 | 33894Ø | 338936 | Ø | Ø |
| -ØØ97P | P | 48 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 1426 | 137ØØ1Ø |
| -ØØ98 | P | 48 | 1352126 | 894958 | 33769Ø | 337688 | Ø | Ø |
| -ØØ99P | P | 49 | 5ØØ 5ØØ | Ø | Ø | - ØØ-ØØ | 985 | 1352126 |
| -Ø1ØØ | P | 49 | 1324722 | 9Ø1454 | 34138Ø | 341376 | Ø | Ø |
| -Ø1Ø1P | P | 5Ø | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | -1479 | 1324722 |
| -Ø1Ø2 | P | 5Ø | 1212258 | 895244 | 33898Ø | 338979 | Ø | Ø |
| -Ø1Ø3P | P | 51 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 716 | 1212258 |
| -Ø1Ø4 | P | 51 | 118Ø734 | 89414Ø | 34147Ø | 341465 | Ø | Ø |
| -Ø1Ø5P | P | 52 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 1821 | 118Ø734 |
| -Ø1Ø6 | P | 52 | 111Ø936 | 894Ø5Ø | 347Ø5Ø | 347Ø44 | Ø | Ø |
| -Ø1Ø7P | P | 53 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 1934 | 111Ø936 |
| -Ø1Ø8 | P | 53 | 1Ø35132 | 894236 | 35969Ø | 359685 | Ø | Ø |
| -Ø1Ø9P | P | 54 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 182Ø | 1Ø35132 |
| -Ø11Ø | P | 54 | 885ØØ6 | 89241Ø | 194Ø4Ø | 194Ø29 | Ø | Ø |
| -Ø111P | P | 55 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 2Ø22 | 885ØØ6 |
| -Ø112 | P | 55 | 782Ø44 | 8916Ø2 | 15484Ø | 154827 | Ø | Ø |
| -Ø113P | P | 56 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 198Ø | 782Ø44 |
| -Ø114 | P | 56 | 13547Ø6 | 894722 | 15968Ø | 159678 | Ø | Ø |
| -Ø115P | P | 57 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 586 | 13547Ø6 |
| -Ø116 | P | 57 | 22949Ø6 | 9Ø223Ø | 18Ø81Ø | 18Ø8Ø6 | Ø | Ø |
| -Ø117P | P | 58 | Ø41 Ø41 | 1 | 3 | ØØ-ØØ | -1183 | 22949Ø6 |
| -Ø118P | P | 1 | Ø2Ø Ø2Ø | 3 | 1 | ØØ-ØØ | 1 | 3 |
| -Ø119 | P | 1 | 3595956 | 892222 | 18Ø83Ø | 18Ø819 | 3 | 1 |
| -Ø12ØP | P | 2 | Ø4Ø Ø4Ø | 3 | 1 | ØØ-ØØ | 1979 | 3595956 |
| -Ø121 | P | 2 | 385524 | 894452 | 1Ø466Ø | 1Ø4658 | 3 | 1 |
| -Ø122P | P | 3 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 46Ø | 385524 |
| -Ø123 | P | 3 | 424Ø58 | 893Ø14 | 9971Ø | 997Ø6 | Ø | Ø |
| -Ø124P | P | 4 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 863 | 424Ø58 |
| -Ø125 | P | 4 | 531Ø46 | 89335Ø | 8989Ø | 89887 | Ø | Ø |
| -Ø126P | P | 5 | 5ØØ 5ØØ | Ø | Ø | ØØ-ØØ | 684 | 531Ø46 |
| -Ø127 | P | 5 | 57531Ø | 9Ø2216 | 8684Ø | 86838 | Ø | Ø |
| -Ø128P | P | 6 | 5ØØ 5ØØ | | | | -562 | 57531Ø |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| -0129 P | 6 | 652212 | 925758 | 23140 | 23077 | -4205 | 652212 |
| -0130P P | 7 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0131 P | 7 | 601846 | 920946 | 95800 | 95731 | -3615 | 601846 |
| -0132P P | 8 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0133 P | 8 | 781804 | 274946 | 81820 | 81761 | 3098 | 781804 |
| -0134P P | 9 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0135 P | 9 | 905340 | 905346 | 84720 | 84709 | -1324 | 905340 |
| -0136P P | 10 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0137 P | 10 | 1083008 | 905244 | 120560 | 120545 | -1849 | 1083008 |
| -0138P P | 11 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0139 P | 11 | 1333626 | 905140 | 98700 | 98688 | -1483 | 1333626 |
| -0140P P | 12 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0141 P | 12 | 1612710 | 895218 | 98170 | 98169 | 219 | 1612710 |
| -0142P P | 13 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0143 P | 13 | 1533146 | 895444 | 148450 | 148449 | 227 | 1533146 |
| -0144P P | 14 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0145 P | 14 | 1344812 | 904334 | 148600 | 148588 | -1883 | 1344812 |
| -0146P P | 15 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0147 P | 15 | 1173046 | 905738 | 164910 | 164886 | -2764 | 1173046 |
| -0148P P | 16 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0149 P | 16 | 1115612 | 920254 | 178340 | 178226 | -6374 | 1115612 |
| -0150P P | 17 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0151 P | 17 | 1071404 | 904052 | 195150 | 195136 | -2319 | 1071404 |
| -0152P P | 18 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0153 P | 18 | 953834 | 902952 | 160110 | 160103 | -1390 | 953834 |
| -0154P P | 19 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0155 P | 19 | 1020748 | 921500 | 139910 | 139802 | -5492 | 1020748 |
| -0156P P | 20 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0157 P | 20 | 900924 | 924012 | 112370 | 112248 | -5234 | 900924 |
| -0158P P | 21 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0159 P | 21 | 782318 | 902910 | 134630 | 134625 | -1142 | 782318 |
| -0160P P | 22 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0161 P | 22 | 780636 | 895836 | 194000 | 193999 | 79 | 780636 |
| -0162P P | 23 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0163 P | 23 | 695638 | 894334 | 240060 | 240057 | 1147 | 695638 |
| -0164P P | 24 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0165 P | 24 | 695232 | 894216 | 295690 | 295686 | 1525 | 695232 |
| -0166P P | 25 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0167 P | 25 | 701752 | 894342 | 370920 | 370915 | 1758 | 701752 |
| -0168P P | 26 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0169 P | 26 | 620440 | 894350 | 200740 | 200737 | 944 | 620440 |
| -0170P P | 27 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0171 P | 27 | 610436 | 893940 | 157510 | 157507 | 931 | 610436 |
| -0172P P | 28 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |
| -0173 P | 28 | 424828 | 914614 | 113770 | 113715 | -3515 | 424828 |
| -0174P P | 29 | 500 500 | 0 | 0 | 00-00 | 0 | 0 |

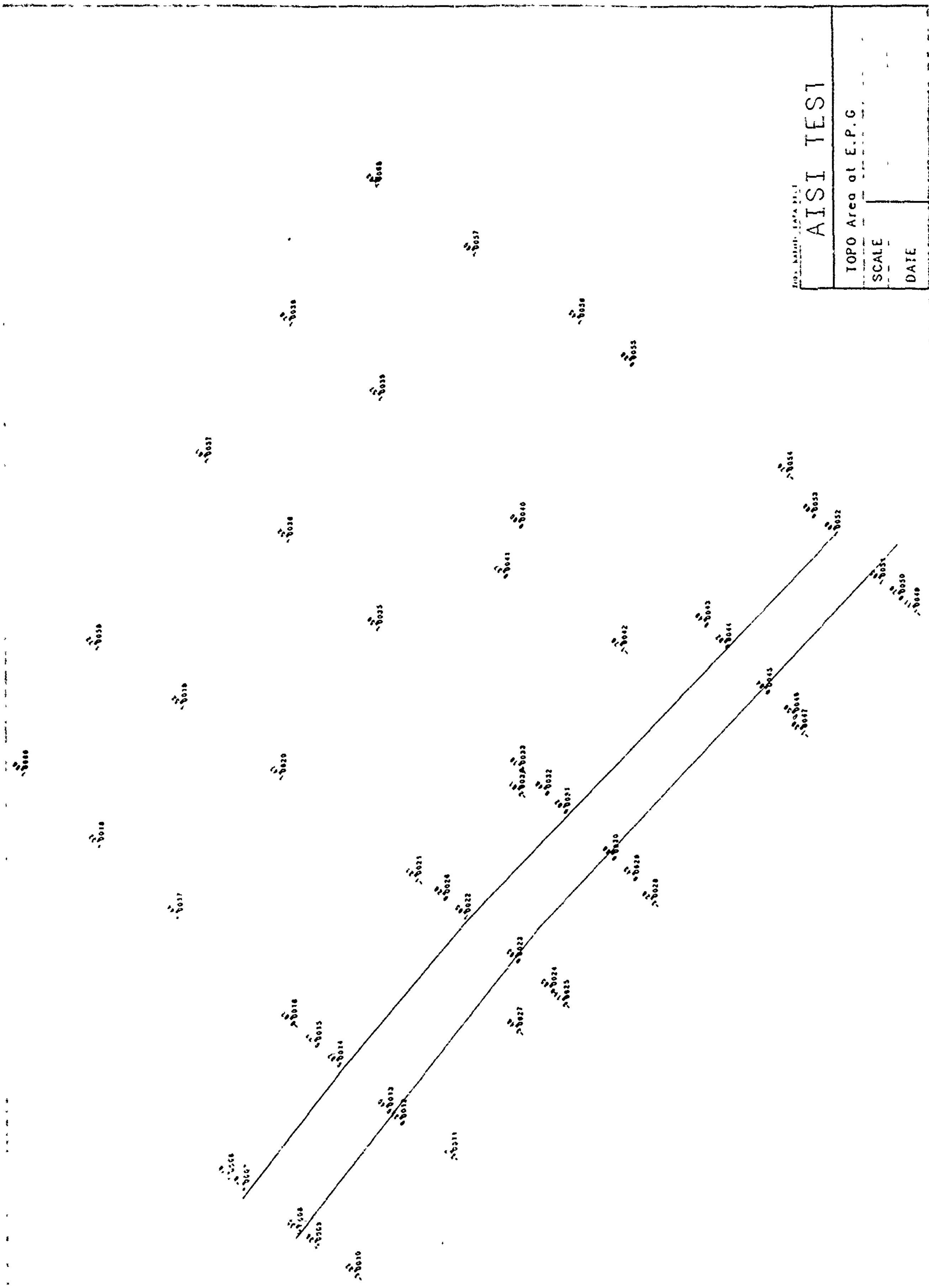



FIGURE 12

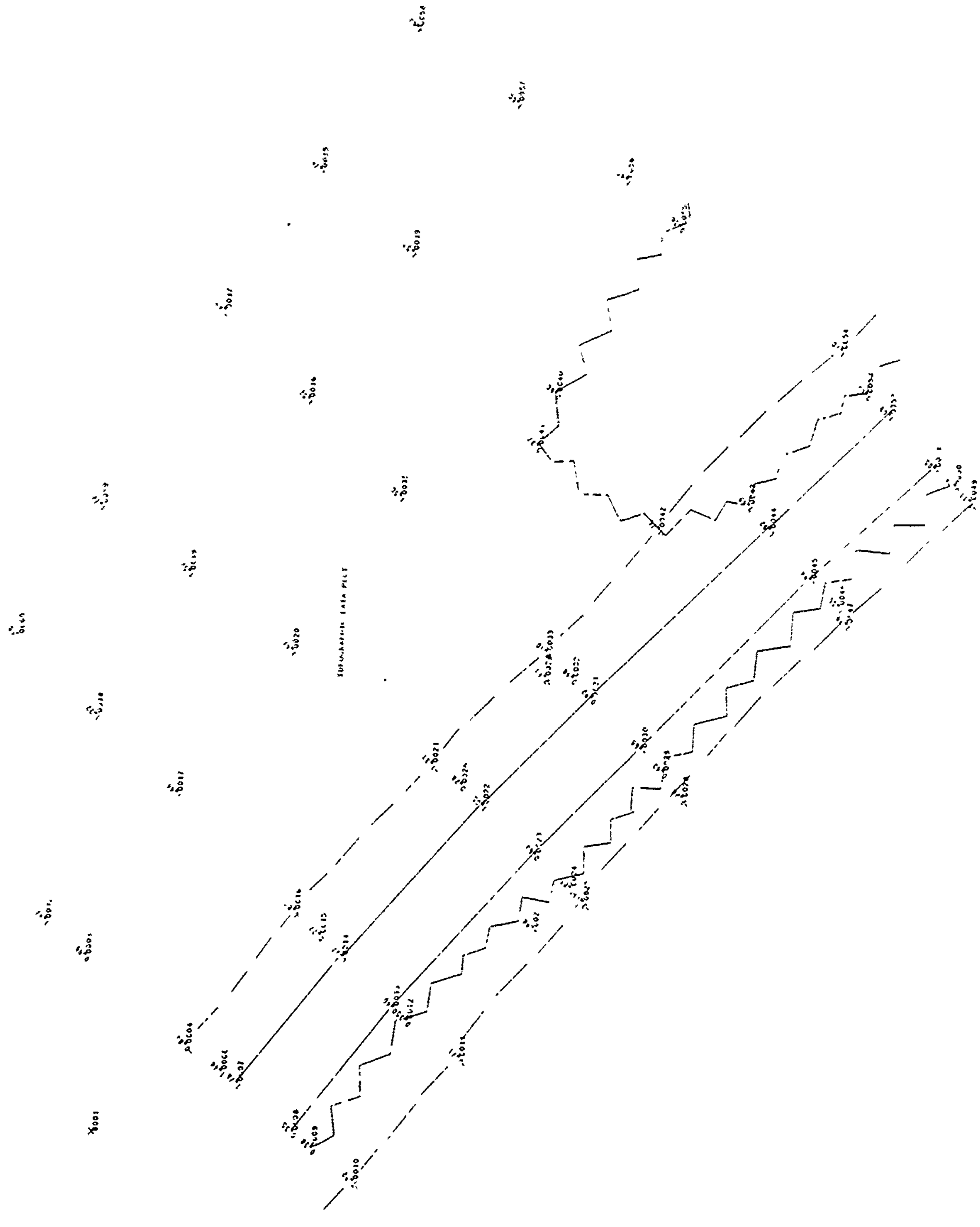


FIGURE 13

1JOB SPECIFICATIONS

```
        CODE=       001(JOB NUMBER AND DATE)
        IN1A=      1234(JOB NUMBER)
        IN2A=    050587(DATE-DAY/MONTH/YEAR)

-------------------------------------------------------------------------

OPT #:   1   BLK #:0001 02   INSTRUMENT SETUP

        CODE=       020(INITIALIZE INSTRUMENT AT NEW SETUP)
        IN1A=     10000(ADDITIVE CONSTANT FOR NORTHING)
        IN2A=     15000(ADDITIVE CONSTANT FOR EASTING)

    NORTHING:       2.250   EASTING:     102.250   ELEVATION:  100.000
-------------------------------------------------------------------------
OPT #:   1   BLK #:0002      MPT #:0002    SEQ #:   2

        HORIZONTAL   VERTICAL    SLOPE     HORIZ    DIFF IN  SCA ADD I
          CIRCLE      CIRCLE   DISTANCE DISTANCE  HEIGHT   COR CON X
         35:41:44   88:57:42    54.640   54.631    0.990   00  00 -

        CODE=       103(BEGIN CURVED LINE SEGMENT)
        IN1A=       006(CENTERLINE OF ROAD)
        IN1B=         1(LINE LOCATION IDENTIFIER)
        IN2A=       .  (WIDTH OF ROAD IN FEET)

    NORTHING:     106.350   EASTING:     156.727   ELEVATION:  100.990
-------------------------------------------------------------------------
OPT #:   1   BLK #:0003      MPT #:0003    SEQ #:   3

        HORIZONTAL   VERTICAL    SLOPE     HORIZ    DIFF IN  SCA ADD I
          CIRCLE      CIRCLE   DISTANCE DISTANCE  HEIGHT   COR CON X
        135:57:50   91: 1:41    40.370   40.363   -0.725   00  00 -

        CODE=       104(POINT ON CURVED LINE SEGMENT)
        IN1A=       006(CENTERLINE OF ROAD)
        IN1B=         1(LINE LOCATION IDENTIFIER)
        IN2A=       .15(WIDTH OF ROAD IN FEET)

    NORTHING:      73.233   EASTING:     130.307   ELEVATION:   99.275
-------------------------------------------------------------------------
OPT #:   1   BLK #:0004      MPT #:0004    SEQ #:   4

        HORIZONTAL   VERTICAL    SLOPE     HORIZ    DIFF IN  SCA ADD I
          CIRCLE      CIRCLE   DISTANCE DISTANCE  HEIGHT   COR CON X
        153:19: 0   88: 7:42    45.310   45.285    1.479   00  00 -

        CODE=       105(END CURVED LINE SEGMENT)
        IN1A=       006(CENTERLINE OF ROAD)
        IN1B=         1(LINE LOCATION IDENTIFIER)
        IN2A=       .15(WIDTH OF ROAD IN FEET)

    NORTHING:      61.788   EASTING:     122.586   ELEVATION:  101.479
-------------------------------------------------------------------------
1
OPT #:   1   BLK #:0005      MPT #:0005    SEQ #:   5

        HORIZONTAL   VERTICAL    SLOPE     HORIZ    DIFF IN  SCA ADD I
          CIRCLE      CIRCLE   DISTANCE DISTANCE  HEIGHT   COR CON X
        159:42:36   87:54:38    48.820   48.787    1.779   00  00 -
```

VersaCAD TWGES FILE. USED TO GENERATE 2D DRAWING FILE

```
ST:S1
VS: 3.0
TT: 7          57  Ø Ø Ø
ST:01
CX:     -56.338     303.662
CY:     -73.994     166.006
BX:     -56.338     303.662
BY:     -73.994     166.006
ST:02
GX: Ø.ØØØØØØ Ø.ØØØØØØ Ø
GY: Ø.ØØØØØØ Ø.ØØØØØØ Ø
SI: Ø.25ØØØØ
IR: 1.57Ø796
SS: 1.ØØØØØØ 1.ØØØØØØ
DT: Ø
AU: Ø
DU: 5
SU: 1
EF: 1.ØØØØØØ
ST:03
CN: 1
TM: 1
SC: 1
LS: Ø
HT: 1
TF: 1
OG: Ø
SY: 1
SO: Ø
WD: 1
RV: Ø
TU: Ø
BL: 1
AL: 1
L1: 111111111111111111111111111
L2: 111111111111111111111111111
L3: 111111111111111111111111111
L4: 111111111111111111111111111
L5: 111111111111111111111111111
ST:04
LV: 1
SC: 1
PN: 1
DN: 1
LW: 1
LS: 1
TF: 1
LZ: Ø.ØØØØØØ Ø.ØØØØØØ
WH: Ø.25ØØØØ Ø.25ØØØØ
EP: Ø.25ØØØØ Ø.25ØØØØ
SF:new
GN: 1
ST:05
H1: Ø.25ØØØØ Ø.ØØØØØØ Ø.785398
H2: 1 1ØØ
SZ: 1Ø24
FR: Ø.25ØØØØ
FD: Ø.ØØØØØØ
CH: Ø.25ØØØØ Ø.ØØØØØØ
TS: Ø.523598
MW: Ø.25ØØØØ
LT: Ø.ØØØØØØ Ø.ØØØØØØ
AT: Ø.ØØØØØØ Ø.ØØØØØØ
LU: 1
```

```
[illegible]
IG: [illegible]
[illegible]
SM: [illegible]
LK: 1 1
DS: 0 0
TA: 1 1
MD: 0 0
IN: 1 1
TL: [illegible]
MT: [illegible]
ST:ES
IN: [illegible]
EN: 1
DS: 0.000000 0.000000
ST:PD
LV:     1
IN:     101.750     101.750
CL:LN
DL:       0.500       0.500
HL: 0
ST:PD
LV:     1
IN:     102.250     102.250
CL:LN
DL:       0.500       0.500
HL: 0
ST:PD
LV:     1
IN:     102.750     101.750
CL:LN
DL:      -1.000       1.000
HL: 0
ST:PD
LV:     7
IN:     102.410     101.290
RT:  0.0000000
CL:WD
WH:       3.536       0.800
TL:  [illegible]
LF:  [illegible]
[illegible]001
ST:PD
LV:     1
IN:     156.477     106.350
CL:LN
DL:       0.250       0.000
HL: 0
ST:PD
LV:     1
IN:     156.727     106.350
CL:LN
DL:       0.250       0.000
HL: 0
ST:PD
LV:     1
IN:     156.727     106.100
CL:LN
DL:       0.000       0.500
HL: 0
ST:PD
LV:     [illegible]
IN:     154.[illegible]     104.088
RT:  2.7552982
CL:WD
WH:       0.480       0.800
```